## ANNOUNCEMENT

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T HE EDITORIAL BOARD and the Publishers take pleasure
in welcoming two new members to the Editorial Board
of the ANNALS OF SURGERY:

**Dr. Robert M. Janes,** *Professor of Surgery, University
of Toronto, Toronto, Canada.*

**Dr. Henry N. Harkins,** *Professor of Surgery, University
of Washington, School of Medicine, Seattle, Washington.*

Dr. Janes will represent Canadian surgery on the Editorial
Board, filling the vacancy created by the death of Dr. Roscoe
Graham. Dr. Harkins, who is Editor-in-Chief of the *Quarterly Review of Surgery,* will make an able representative
from the Pacific coast.

The addition of these two surgeons brings the number on
the Editorial Board to the former figure of twelve. The Publishers and the Editorial Board extend a hearty welcome to
these two new members, who will help carry on the high
standards of excellence of the ANNALS OF SURGERY.

—JOHN H. GIBBON, JR., M.D.

# RESULTS FOLLOWING SUBTOTAL GASTRECTOMY
## FOR DUODENAL AND GASTRIC ULCER *

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DURING THE DECADE 1936 TO 1945, inclusive, 394 partial gastric resections were performed for peptic ulcer at the Presbyterian Hospital in New York City. In view of the current discussion of the relative virtues of vagus nerve resection and gastric resection, a review of these cases is reported at this time. The cases reviewed include both ward and private. They were operated on by all members of the general surgical staff and in about a quarter of the instances by the surgical residents, usually assisted by a staff member. The results are therefore not to be attributed to the skill of a specialist in this field of surgery, but are those obtained in a teaching institution.

### OPERATIVE TECHNIC

In most instances, a Polya type of resection was done, the jejunal loop for anastomosis being brought up anterior to the colon more often than posterior. Recently, the Hofmeister procedure with a short posterior loop has been carried out most frequently. It has not been possible to show any consistent difference in the early or late results of the Polya type of resection whether the anterior or posterior type of anastomosis was done or whether the ulcer was removed, cut through or left in. In some instances when a duodenal ulcer was left in, the pylorus and even part of the antrum were left in as well, but the mucosa was removed. These cases have done as well as the rest. In the Polya types of resection it has seemed to make no difference whether the anastomosis was done isoperistaltic or antiperistaltic. It has been our impression that there are less immediate postoperative difficulties after the Hofmeister type of resection than after the Polya type, as has been noted in other clinics. We have not yet had an opportunity to compare the late postoperative results following these two procedures, but it appears that the Hofmeister type will do at least as well. An effort has been made in nearly every resection, whatever the type, to remove two-thirds or more of the stomach, so that this series differs from older ones which included pylorectomies. No occlusion procedures leaving in the mucosa were done, and no two-stage procedures. In a few instances, a jejunoplasty was tried, uniting the afferent and efferent jejunal loops in a manner similar to a Finney pyloroplasty.

The cases subjected to resection were, in general, the ones whose symptoms were severe. No standard criteria are set up in the hospital to determine when operation should be done, but the indications usually are either suspicion

of carcinoma or chronicity of symptoms indicating failure of medical treatment
to control pain, repeated hemorrhages or persistent obstruction. This report
does not include cases which were operated on as emergencies for perforation
or bleeding, nor does it include cases where a previous gastro-enterostomy
was taken down at the time of the resection, although the last complication
has added nothing to the postoperative death rate or subsequent recurrence
of symptoms.

### METHOD OF POSTOPERATIVE ANALYSIS

The chief value of the report lies, we believe, in the completeness of the
record of what has happened to the patients after they have left the hospital.
This is the result of the efficiency of the Follow-Up Clinic which has been
administered now for thirty years by Miss Retta Pinney. For many years
the two senior authors have spent two full and busy mornings each fortnight

TABLE I.—*Partial Gastrectomy for Ulcer*
Number of Cases Being Followed

| | | |
|---|---|---|
| Currently followed, i.e. seen or heard from in 1945 or 1946...... | 344 | 87.3% |
| Died in hospital or after from any cause........................ | 37 | 9.4% |
| Lost to follow-up ............................................. | 13 | 3.3% |
| | 394 | 100.0% |

Of the lost cases all but three had been followed for at least one year.
Of the currently followed cases about 90% had been personally interviewed in
1945 or 1946; the remainder heard from by letter.

TABLE II.—*Partial Gastrectomy for Ulcer.* Follow-up Results

| Group | | Number of Patients |
|---|---|---|
| 4 | 271 | |
| 3 | 65 | |
| Total of Satisfactory Cases................. | | 336 |
| 2 | 17 | |
| 1 | 20 | |
| Total of Unsatisfactory Cases.............. | | 37 |
| Insufficient Data ...................................... | | 3 |
| Postoperative Deaths ............................... | | 18 |
| Total ..................................... | | 394 |

in this Clinic, interviewing and examining patients who have had gastric
operations. We estimate that over 80% of the follow-up records are based
on personal interview either in this Clinic or in private practice, the remainder
being the result of communication with patients who cannot be reached for
interview. There is no substitute for the personal interview as a means of
finding out what the patient's state of health is. The status of the 394 patients
on July 1, 1946, with a few subsequent corrections, was as shown in Table I.

Each time a patient is seen or heard from, he is rated as to his follow-up
status on an anatomic, symptomatic and economic basis. This report has to do
only with the symptomatic rating. The symptoms considered are those which
seem to be related to his ulcer or his operation. A scale of four is used. A
rating of four means no symptoms; a rating of three means mild complaints,
but hardly beyond the range which a well person might have. Ratings of four

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TABLE III.—*Partial Gastrectomy for Ulcer. Unsatisfactory Cases*

1. *Cases Unsatisfactory Because of Symptoms Suggesting Persistent Ulcer*:
   a. Proved jejunal ulcer:
      703298   K.   Perforated jejunal ulcer 2½ years after resection.
      701898   N.   Jejunal ulcer 2 years after resection. Died as a result of operation on this ulcer.
   b. Persistent pain or bleeding. Possible jejunal ulcer:
      689322   F.   Report once suggested recurrent ulcer. Not seen at follow-up since 1942. Now reports he is symptom free.
      761845   G.   Tarry stools four days with pain, 2½ years after resection. Smoking too much. Roentgen-ray showed possible ulcer of efferent loop. Now symptom free.
      777565   D.   Three episodes of bleeding in 8 years. Roentgen-ray once suggested a jejunal ulcer. Small resection.
   c. Bleeding, otherwise symptomless:
      813904   M.   Episodes of tarry stools. No other symptoms. Source of bleeding not found. Roentgen-ray showed no lesion.
   d. Gastro-intestinal symptoms suggesting ulcer syndrome, but no ulcer demonstrable and no bleeding:
      665392   P.   Generally much better than before operation. State of well-being varies from day to day. Nervousness, irritability, despondency, some pain and occasional vomiting.
      565880   S.   For 5 years, fullness and gaseous distress after meals, empty feeling between meals, dizziness, some loss of weight. Now no digestive complaints, but lack of energy and strength.
      580765   G.   Persistent vomiting immediately after leaving hospital, but last letter stated she felt much better. Lives in South Africa. Lost to follow-up at 6 months.
      749020   K.   Many complaints after operation, only 2 of which were directly gastro-intestinal in nature. Seemed psychoneurotic. Anxious to prove poor health will not permit him to be deported to Central America whence he came. Jejuno-plastic operation.

2. *Cases Unsatisfactory Because of Effects of Operation:*
   a. Late Infection or obstruction:
      680254   L.   Adhesions distal to stoma causing partial ileus, not wholly relieved by three operations. Jejuno-plastic operation.
      561763   B.   Died 6 months after resection with esophageal stricture and subphrenic abscess from duodenal fistula.
      242616   C.   Died following second operation which was done for intussusception near stoma. Originally gastric ulcer.
      416007   W.   Died following second operation done for obstruction of afferent loop. Originally gastric ulcer.
      603964   O.   Died following second operation. Afferent loop leading to lesser curvature had become constricted behind mesentery of efferent loop, causing ileus, gangrene, peritonitis.
   b. Late hemorrhage:
      517123   H.   Died following second operation to check a severe hemorrhage from superior pancreatico-duodenal vessels, 23 days after resection.
   c. Pulmonary tuberculosis, activated by operation:
      657949   W.   Developed active tuberculosis while in hospital after operation. Dead in 6 months. Originally gastric ulcer.
   d. Spinal cord damage from spinal anesthesia:
      703328   K.   Incapacitated as result of spinal cord damage.

3. *Unsatisfactory for Miscellaneous Reasons:*
   a. Digestive symptoms probably not caused by ulcer:
      820454   McM.   Repeated brief episodes of abdominal pain, nausea and vomiting. Has regional ileitis.
      605468   S.   Chronic invalid. Psychoneurotic. Persistent malnutrition. Roentgen-ray showed no lesion except slow emptying of gastric pouch, after operation.
      502188   B.   Symptoms of intestinal obstruction on two occasions after operation. Hard to say whether ulcer recurrence played a part. Jejunoplastic operation.
      740173   K.   Persistent epigastric symptoms. No explanation found by roentgen-ray. No ulcer found at operation. Symptoms after operation similar to those before, but less frequent, and no bleeding.

TABLE III (Continued)

b. Bleeding shortly after operation, then satisfactory:
   559888  P.  Bled shortly after operation. Now over two years symptom free.
   547353  G.  Hematemesis one month after operation. No subsequent bleeding for
               three years.

c. Unsatisfactory after operation; now symptom free but follow-up is short:
   786292  D.  Occasional vomiting while smoking heavily four months after operation.
               Symptom free since, for one year.
   767851  S.  Unsatisfactory first 6 months. Too early to rate finally. No symptoms
               now. Duodenal and gastric ulcer.

d. Secondary operation needed. Symptom free thereafter:
   593806  H.  Division of peritoneal bands nearly five years after operation.
   568974  B.  Entero-enterostomy necessary for dilated gastric loop. Five years
               since, symptom free. Originally gastric ulcer.
   660994  L.  Division of adhesions two years after operation.
   567938  M.  Efferent loop blocked by adhesions, requiring second operation.
   620990  R.  Adhesions remote from original operation in left lower quadrant.
               Originally gastric ulcer.
   675259  A.  Entero-enterostomy six weeks after operation.
   675436  E.  Wound infection, septicemia, abscess of kidney. Hemolytic staphylo-
               coccus aureus, requiring two hospitalizations with operation. No im-
               portant gastric symptoms.
   741120  S.  Postoperative hernia requiring repair.
   423620  E.  Infected sinuses in wound requiring two operations.

e. Secondary operation needed. Short follow-up:
   791569  M.  Two operations for intestinal kinks and a new anastomosis made at a
               third. Too soon to appraise final results.

f. Gastric carcinoma, perhaps present at operation for ulcer above site of resection:
   481379  C.  Bleeding continued after operation, beginning less than one year after
               resection. Carcinoma of fundus resected three years after resection for
               ulcer. Died.

and three are considered satisfactory. Two and one indicate unsatisfactory ratings. In the great majority of instances there is no difficulty in giving a rating. At times questions arise, particularly in neurotic patients, of whether complaints are severe enough to warrant an unsatisfactory rating or whether or not they are related to the ulcer syndrome or to the operation. The effects of worry, tension and indiscretions in eating and drinking present themselves at times for consideration. It is easy, for instance, to say that a patient crippled with arthritis is still satisfactory from the standpoint of ulcer therapy, but conditions such as ileitis or diverticulitis or psychoneurosis may give rise to confusion. In such cases, one can only use one's best and honest judgment, recalling that the object of the rating system is to find out the truth and not to promote or condemn any form of therapy which has been employed.

This method of rating leads to some incongruous results. Several patients who say they are much improved since the operation are nevertheless rated as unsatisfactory. On the other hand, a few patients have been called satisfactory in spite of the fact that they may vomit at times or cannot gain as much weight as they want. It is our experience that the group who do not at first gain weight may gain after a year or two, although some patients never do but are well and working. Especially during the first year, patients may vomit from overloading their stomachs with meals which would not disturb a normal person. Unless this symptom were pronounced we would not consider that it rendered them unsatisfactory but would place them in Group 3. There

are a few people who complain of sweating and weakness after eating, the so-called "dumping syndrome," but, if these symptoms are not severe, they are similarly regarded. This is an interesting phenomenon, as yet unexplained.

TABLE IV.—*Partial Gastrectomy for Ulcer*. Postoperative Complications

| | |
|---|---|
| No complications | 161 |
| Pneumonia | 92 |
| Atelectasis | 13 |
| Pulmonary embolus | 4 |
| Pulmonary infarct | 5 |
| Spasm or obstruction of efferent loop | 12 |
| Spasm or obstruction of afferent loop | 2 |
| Excessive vomiting | 32 |
| Slow gastric emptying | 3 |
| Biliary fistula | 24 |
| Pancreatic fistula | 2 |
| Gastrointestinal hemorrhage | 9 |
| Hemorrhage from other source | 3 |
| Diarrhea | 11 |
| Severe amigen reactions | 8 |
| Other infusion reactions | 3 |
| Shock | 2 |
| Wound infection | 14 |
| Infection of drainage tract | 8 |
| Disruption | 5 |
| Urinary retention | 15 |
| Headache | 4 |
| Meningismus | 2 |
| Unexplained fever | 12 |
| Phlebitis | 5 |
| Auricular fibrillation | 3 |
| Distension | 5 |
| Parotitis | 4 |
| Pancreatitis | 4 |
| Jaundice | 3 |
| Cerebral accident | 2 |
| Cardiac failure | 1 |
| Coronary occlusion | 1 |
| Paroxysmal tachycardia | 1 |
| Other tachycardia, unexplained | 1 |
| Psychosis | 1 |
| Convulsion | 1 |
| Transfusion reaction with uremia | 1 |
| Asphyxia (blood in trachea) | 1 |
| Upper respiratory infection | 3 |
| Pelvic abscess | 1 |
| Gangrene of colon | 1 |
| Gangrene of jejunum | 1 |
| Massive pulmonary collapse | 1 |
| Massive pleural effusion | 1 |
| Acute pulmonary TBC | 1 |

NOTE: Incidence of acute diffuse peritonitis and peritoneal abscess difficult to determine.

### POSTOPERATIVE RESULTS

Over the years, as the follow-up visits multiply, a record emerges of the patient's state of well-being since the operation. In Table II is given a summary of the results. In this Table the patients are grouped according to the lowest rating to which they fell during their follow-up course, with the exception that ratings during the first postoperative year, while the patient is becoming adjusted to his new digestive mechanism, are sometimes disregarded. To

achieve a Group 4 rating a patient must never have fallen below a four after his first year; a single drop to Group 3 or Group 2, for instance, would place him in that lower group.

TABLE V.—*Partial Gastrectomy for Ulcer*. Postoperative Deaths

| Chart No. | Age | Carcinoma Suspect | Day Post-op | Autopsy | Apparent Causes of Death |
|---|---|---|---|---|---|
| 369171 | 60 | No | 4 | Yes | Pneumonia. |
| 444085 | 60 | No | 8 | No | Pneumonia. Leaking duodenal stump. Peritonitis. |
| 564823 | 58 | No | 6 | Yes | Gangrene of jejunum following occlusion of superior mesenteric artery due to arteriosclerosis of aorta. |
| 588457 | 48 | Yes | 5 | Yes | Gangrene of transverse colon. |
| 557952 | 60 | Yes | 1 | Yes | Massive collapse of lungs. Had Stokes-Adams syndrome. |
| 544719 | 62 | Yes | 7 | No | Atelectasis, auricular fibrillation, pulmonary embolus. |
| 645412 | 30 | No | 7 | No | Bile peritonitis, probably from leaking duodenal stump. |
| 630929 | 63 | Yes | 11 | No | Cerebral vascular accident. |
| 699731 | 61 | Yes | 12 | Yes | Disorientation, pneumonia, incontinence, decubiti, hypoproteinemia, coma, heart failure, subhepatic abscess from leaking duodenal stump. |
| 728277 | 50 | No | 17 | Yes | Pneumonia, leaking duodenal stump with abscess, severe distention (not mechanical), diffuse peritonitis, pancreatic fat necrosis, hiccough, jaundice. Irrational. |
| 601089 | 50 | No | 16 | No | Pulmonary embolus. |
| 733712 | 64 | No | 11 | Yes | Transfusion effect probably. Uremia, jaundice, hiccough, pneumonia. |
| 752813 | 65 | Yes | 2 | No | Long operation. Shock, coronary occlusion. |
| 751735 | 43 | Poss. | 8 | No | Bronchopneumonia, distention, disruption with evisceration, inhaled vomitus during closure of disruption, fatal pneumonia. |
| 772174 | 52 | Yes | 6 | Yes | Hypertensive 220/120. Mild heart failure. Biliary fistula. Cause of death uncertain. |
| 783912 | 49 | No | 30 | No | Pneumonia, delirium, subhepatic abscess from leaking duodenal stump, hemorrhage into abscess, jejunostomy feedings. |
| 797516 | 73 | Yes | 5 | Yes | Pulmonary embolus, infarct of lung, pneumonia. Thrombus in right femoral vein. |
| 801055 | 48 | No | 44 | No | Spinal anesthesia. Acute meningitis beginning 15th day after operation. |

As appears in Table II, by our standards 336 patients have never been unsatisfactory since their operation. This number is 85% of all the patients who underwent resection, or 90% of all the patients followed (disregarding the postoperative deaths and the three not followed). An encouraging fact is that no case which went for five years without becoming unsatisfactory thereafter fell into an unsatisfactory group. This is in striking contrast to the record following posterior gastro-enterostomy, in which each year brought new failures. In this series, 99 persons were followed for five years, of whom 12% became unsatisfactory, while of the larger number followed for less than five years, 9% became unsatisfactory. The difference is not significant.

### ANALYSIS OF UNSATISFACTORY CASES

Of the cases rated as unsatisfactory in Table II, some should not be so regarded without qualification. Two groups stand out as clearly unsatisfactory, viz., those who had symptoms suggesting persistent ulcer and those who had uncorrected harmful effects from the operation. The remainder of the cases called unsatisfactory are so rated because they have to be differentiated from the group that was consistently satisfactory, but they cannot be said to have been treated unsuccessfully from the standpoint of their ulcers. Table III elaborates these statements.

Table III contains several facts of interest. It shows that the incidence of proven jejunal or marginal ulcer has been two out of 373 cases that survived operation and were followed. In three others, jejunal ulcer may have occurred. In no other case has its presence been seriously suspected. The incidence has been, therefore, somewhere between 0.5% and 1.4%. The number of patients whose symptoms suggested persistent ulcer syndrome is 10, about 2.7%. There were eight whose difficulties stemmed from the operation or the anesthesia, of whom six died. These will be mentioned later when the postoperative deaths are discussed. There are four who have digestive complaints which do

TABLE VI.—*Partial Gastrectomy for Ulcer.* Chief Causes of Postoperative Deaths
The causes of death often were multiple, but the apparent chief causes can be grouped as follows:

| | |
|---|---|
| Duodenal stump complications | 4 |
| Pneumonia | 3 |
| Pulmonary emboli | 3 |
| Massive collapse of lung | 1 |
| Transfusion effect | 1 |
| Gangrene of transverse colon | 1 |
| Thrombosis of superior mesenteric artery | 1 |
| Cerebral accident | 1 |
| Coronary occlusion | 1 |
| Meningitis | 1 |
| Uncertain | 1 |

Duodenal stump complications were a secondary cause of death in 2 of the above cases; pneumonia of serious degree in 3.

not seem to be a continuation of the ulcer syndrome, 14 who had transient difficulties not apparently due to ulcer, and one who died of gastric carcinoma which might have been present at operation. It is a matter of opinion how to consider the last-named groups, which total 19, when appraising the success of the operation as a means of treating ulcer. It may be leaning over backwards to rate them as unsatisfactory. Another interesting fact which does not show in the table is that every case that had persistent digestive symptoms after operation had a duodenal ulcer before; no gastric ulcer gave symptoms after operation except such as could be attributed to the operation itself. The patients listed in the table had duodenal ulcers unless otherwise recorded.

### POSTOPERATIVE COMPLICATIONS IN HOSPITAL

Table IV gives the incidence of postoperative complications that occurred while the patients were in the hospital, as they are recorded on the charts. The list is probably not wholly accurate but gives an approximate picture of

the important difficulties. The recorded incidence of atelectasis is probably far too low. The cases grouped under this heading are those with signs of atelectasis but with clinically minimal accompanying pneumonia. Most of the pneumonias we believe started with atelectasis but this does not appear in the table. One hundred sixty-one patients got well without complications. The pulmonary complications were the most frequent. Next came persistent vomiting, which in some instances was attributable to spasm or obstruction of the efferent jejunal loop. The high incidence of biliary fistulae may be due to the fact that in most of the cases a drain was placed down to the region of the duodenal stump. We adopted the practice of draining the region of the duodenal stump because we had found that in the previous decade the chief cause of our postoperative fatalities had been leakage from the stump. Drainage has not fully solved the problem. In spite of drainage, there have been fatalities due chiefly to duodenal stump leakage, although the deaths from this cause have been fewer in number since drainage was adopted. Certainly the bile fistulae have occurred too frequently but most of them have been little more than an annoyance and, in patients who survived, all have healed spontaneously, usually within two weeks. It may be that with the Hofmeister type of procedure there will be fewer cases of back pressure in the duodenum, which we have believed to be one of the causes of fistulae developing in the past. It may be possible also to learn to recognize which stumps are insecurely closed and should therefore be drained in a manner that can take care of anticipated profuse leakage. We realize that there are clinics whose recorded death rate is lower than ours, in which drainage is rarely employed.

### POSTOPERATIVE DEATHS

The list of postoperative deaths is set forth in Table V. The first item of note is the age of the patients that died. Of the 18 deaths, 16 occurred in patients over age 45, and 13 in patients over age 50. The postoperative mortality among patients under age 45 was about 1%; over this age it was 7.6%. These figures emphasize the safety of the operation in the relatively young and the need for caution and careful study before recommending resection in people of more advanced years. One hundred and eighty-four patients age 45 and under were operated on, and 210 over age 45. One reason why so many people over age 45 were operated on was the fear that the gastric lesion might be carcinoma. This brings up the question of how useful resection of the vagus nerves would be as a substitute for resection in treating these older patients. Certainly the abdominal approach would be necessary but, even with this, the surgeon, as we have come to know well, often cannot distinguish between benign and malignant ulcers at the time of operation. Even quick frozen section in this field is unreliable. In each instance of gastric or pyloric ulcer which the surgeon thinks benign, he must choose between exposing his patient to the higher operative risk which accompanies resection or the higher risk of leaving in malignant disease which accompanies vagus nerve resection. It is our opinion that progress can be made in cutting down the postoperative death rate after resection but that little progress can be made in recognizing

early carcinoma in the gross, and we therefore favor a policy of resection for these cases unless clearly contraindicated. This point is well exemplified by an increasing number of cases (some 33 or more) of superficial spreading carcinoma of the stomach observed by us and described by Dr. A. P. Stout of the Surgical Pathology Laboratory, in which the mucous membrane and submucosa are involved alone, and also by the not inconsiderable number of cases with carcinoma in a limited area of an otherwise microscopically benign ulcer.

TABLE VII.—*Partial Gastrectomy for Ulcer.* Cases Done Prior to 1936

I. Operations in Decade 1926-1935:

    A. Followed 10 to 20 Years (Average 13 Years)     —     32 Cases

        Present Follow-Up Status:

            Still currently followed.................. 25

            Dead, not of ulcer...................... 4

            Lost .................................. 3

        Follow-Up Result:

            Satisfactory ........................... 26

            Unsatisfactory ......................... 6

    B. Followed Less Than 10 Years (Average 5 Years)     —     17 Cases

        Present Follow-Up Status:

            Dead, not of ulcer...................... 6

            Dead, of ulcer ........................ 1

            Lost .................................. 10

        Follow-Up Result:

            Satisfactory ........................... 13

            Unsatisfactory ......................... 3

            No record ............................ 1

    C. Postoperative Deaths (12%)     —     6 Cases

          TOTAL OPERATIONS 1926 - 1935     —     **55**

II. Operations in Decade 1916 - 1925:

    A. Followed 10 to 27 Years (Average 20 Years)     —     25 Cases

        Present Follow-Up Status:

            Still currently followed.................. 14

            Dead, not of ulcer...................... 8

             Lost .................................. 3

         Follow-Up Result:

            Satisfactory ........................... 21

            Unsatisfactory ......................... 4

    B. Followed Less Than 10 Years (Average 3.5 Years)     —     19 Cases

        Present Follow-Up Status:

            Dead, not of ulcer...................... 5

             Dead, cause unknown .................. 1

            Lost .................................. 13

        Follow-Up Result:

            Satisfactory ........................... 10

            Unsatisfactory ......................... 4

            No record ............................ 5

    C. Postoperative Deaths (20%)     —     9 Cases

        TOTAL OPERATIONS 1916 - 1925     —     53

The causes of postoperative deaths were often multiple, but the apparent chief causes can be grouped as in Table VI. We are reasonably sure of the accuracy of this table as autopsies were obtained in nine of the 18 fatalities. Among those not autopsied the causes of death were in most instances clear, viz., two pulmonary emboli, one cerebral vascular accident, one coronary occlusion, one aspiration pneumonia, one meningitis. The other three cases not subjected to autopsy had leakage of the duodenal stump which was obviously the main cause of death.

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It is to be noted that in this series there was no death resulting from hemorrhage during the immediate postoperative period or from leakage at the suture line at the anastomosis or from obstruction about the stoma. The chief objectives of our efforts to lower the postoperative death rate in the future will be: first, more intensive study of patients over age 50 and their indications and contraindications for radical surgery; second, attempts to lower the incidence of leakage of the duodenal stump (and, in this regard, we believe that the simple Hofmeister post-colic procedure will eliminate, to a considerable degree, the back pressure occurring at times with the anterior types of anastomoses); third, attempts to lower the incidence of pulmonary complications.

The postoperative death rate was 4.6% (18 died in the hospital). To these must be added seven others who died after leaving the hospital as a result of failure of the operation. These cases are included among the unsatisfactory ones listed in Table III. They are as follows: one with proved jejunal ulcer; four with late infection or obstruction; one with severe bleeding from the pancreatico-duodenal vessels; one with pulmonary tuberculosis re-activated by the operation. The patient who died with gastric carcinoma is not included in this list. These bring the operation death rate to 6.4%, if all the patients are included who died of their ulcer or the effects of operation, in the hospital or after they had gone home.

#### PATIENTS FOLLOWED OVER TEN YEARS

In Table VII are given summaries of the resections done for ulcer prior to 1936. Because of the relatively high mortality in those years, the operation was usually done only as a last resort in treatment. In the decade 1916 to 1925, wide resection of the stomach was not done for ulcer. These operations were little more than pylorectomies. During the following decade, 1926 to 1935, more extensive resections were beginning to be done, but rarely as wide as has been standard during the past 10 years. For this reason it is not possible to compare the follow-up results of the three decades with each other. The chief interest in these old cases lies in the number of them who have been followed for 10 years or more.

In the decade 1926 to 1935 there were 55 cases, of whom 40 remained satisfactory, which is 73% of the 55 cases and 83% of the followed cases, omitting the postoperative deaths and one case that was not followed. Of these 40, 27 were followed for 10 to 20 years. None of the cases that remained satisfactory for five years thereafter became unsatisfactory.

In the decade 1916 to 1925, when pylorectomies were being done, there were 53 cases, of whom 31 remained satisfactory, which is 59% of the 53 cases and 80% of all the followed cases. Of the 31, 21 were followed for 10 to 27 years.

In the two decades 1916 to 1935, 15 cases have been followed for 20 or more years and 48 for 10 years or more. Among the cases of the earliest decade are three who became unsatisfactory for the first time after more than five satisfactory years. They are the only ones in our records that did this. They all had what we should now consider inadequate resection and do not

vitiate the rule that in carefully followed cases, primary recurrences are rarely found after five good postoperative years where there has been adequate resection.

## COMMENT

The above record of the experience of a general surgical service with subtotal gastrectomy for peptic ulcer may help to resolve some of the controversy concerning the form of therapy which should be adopted for these lesions. Certain aspects of this record seem to us to be especially important. These are: 1) The high percentage of excellent results which have followed this operation. Very few of the cases called satisfactory are restricted in their diets, most of them smoke, and many indulge in alcohol. Their life and occupation are not interrupted by recurrence of ulcer symptoms. They are the antithesis of "gastric cripples." Few among them have digestive complaints beyond the range of normal man. There is reason to believe that recurrences among this group in the future will be infrequent because none among them who has gone five years without recurrence later developed symptoms.

2) For people under age 45, resection is a relatively safe procedure, the hospital postoperative mortality in our hands being about 1%.

In view or 1) and 2) and the absence as yet of any studies based on long follow-ups in cases in which vagus resection has been performed, we lack the evidence to justify us in advising our younger ulcer patients to have vagus section performed. We are waiting with keen interest to see the reports of five and ten year results of this experimental procedure. For patients under 45 or 50 years of age, we see little reason for withholding resection. Some patients in this age group, of course, will provide exceptions to those general statements.

3) For patients of the older age group the problem of therapy becomes more complicated. We do not attribute any particular importance to age 45 but about that time the fear of carcinoma comes more frequently into the picture and postoperative troubles multiply. Among this group, patients who have lesions of the stomach which, after careful study, are not free of suspicion of being carcinoma, should as a rule be subjected to resection. In individual cases this rule can be modified depending upon how strong the evidence for carcinoma is and the patient's apparent ability to stand the operation.

It is most difficult to dictate the form of therapy that should be used in people of the older age group whose ulcer is in the duodenum and in whom carcinoma is almost surely absent. If these people bleed, their risk of death is relatively higher than in the younger age group. If their symptoms are intractable under a medical regimen, as they often are, one must consider either a different form of medical therapy or surgery. If surgery is decided upon, the low mortality of vagus nerve section is appealing, provided it is found that it arrests symptoms for long periods, which as yet there has been insufficient time to show.

4) Whereas psychic factors undoubtedly play an important role in relation to ulcers, they have not interfered seriously in many cases in this series with the benefits of surgery. Some of the unsatisfactory cases seem to have an

organic basis for their complaints. On the other hand, not a few patients who gave the impression of being psychoneurotic before operation lost this characteristic after being free of their pain or bleeding. If a patient under 45 has a demonstrable, intractable ulcer, it may be well to relieve him of his organic cause of distress, even if doing so does not wholly free him from functional defects. In these cases especially, is the wise physician most needed.

5) The decade covered by this report includes the war years when the staff of attending surgeons, resident surgeons, anesthetists and nurses were not as complete as it now is. The current postoperative mortality and morbidity during 1946 and 1947 have shown improvement over those of previous years here reported.

6) It is interesting to note the steady improvement in postoperative mortality in a teaching institution during the past thirty years. In the decade 1916-1925 the rate was 20% ; in the decade 1926 - 1935 the rate was 12% ; in the decade 1936 - 1945 the rate was 4.6% ; in the two years 1946, 1947, the rate was 2.5%.

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# THE PROBLEM OF PEPTIC ULCER
## FOLLOWING PANCREATECTOMY °

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MANN AND WILLIAM IN 1923 demonstrated, in dogs, that after an operation short-circuiting the alkaline duodenal contents, bile and pancreatic juice into the lower small bowel, a marginal jejunal ulcer forms at the gastrojejunostomy site, due to the action of unneutralized gastric juice. This operation consisted of transecting the duodenum at its proximal and distal ends, leaving the bile and pancreatic ducts attached in normal position to the duodenum. The proximal end of the duodenum was closed and the distal end was anastomosed to the side of the lower ileum. The open end of the jejunum was then sutured to the pylorus. (Fig. 1). Fourteen dogs out of a group of 16 thus treated and followed over a period of time developed typical peptic ulcers in the jejunum adjacent to the site of the anastomosis with the stomach. Repetition of this experiment by others has consistently confirmed the results.

In another series of experiments the bile and pancreatic ducts were transplanted to the lower ileum. The majority of animals so treated developed ulcers in the duodenum. Peptic ulcers likewise form in the intestine distal to the pylorus in dogs in which the bile and pancreatic ducts are transplanted into the ileum and in addition the duodenum is resected. On the other hand those dogs in which the duodenum was resected and the bile and pancreatic ducts were implanted into the jejunum at about the same distance from the pylorus as they were originally, remained in good condition for long periods.

Exalto[2] in 1911 and Matthews and Dragstedt[3] in 1932 in similar experiments demonstrated the importance of neutralizing duodenal content in the prevention of peptic ulcer.

Peptic ulcers may form in like manner in man following pancreatoduodenectomy in which the bile duct is anastomosed to the jejunum distal to the gastroenterostomy, and the pancreatic duct, in case of subtotal pancreatectomy, is ligated. One of these procedures was done in each of the following cases.

A man of 59 years was operated upon for suspected carcinoma of the pancreas. At operation the pancreas was hard except for two large cystic areas. It was impossible to determine whether this was carcinoma or pancreatitis or both; therefore, because of the severity of symptoms, total resection of the pancreas was carried out. Pathologic study revealed a severe chronic pancreatitis with an intraductile papilloma obstructing the main pancreatic duct near the ampulla of Vater. The patient made a very satisfactory postoperative recovery except for the development of a postoperative hernia in one portion of the wound.

In restoring the bowel continuity, a proximal anterior gastrojejunostomy and a distal cholecystenterostomy were made. An enteroenterostomy was made

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between the two previous anastomoses (Fig. 2). The patient was well until four months after operation when he was prostrated by sudden severe abdominal pain which came on without warning while he was at work hanging a new window in his home. When seen 24 hours after the onset of symptoms the patient was moribund. Exploration revealed a two centimeter sized perforation of the anterior wall of the jejunum at the site of the gastrojejunostomy. The perforation was closed but the patient died of peritonitis in spite of intensive supportive therapy. Autopsy revealed the surgically closed ulcer and another superficial ulcer adjacent to it at the line of junction of the jejunum and stomach. The entero-anastomosis designed to protect the biliary system from gastric and intestinal content had diverted the bile from the gastro-enterostomy stoma leaving the jejunal mucosa to the direct action of unneutralized gastric juice.
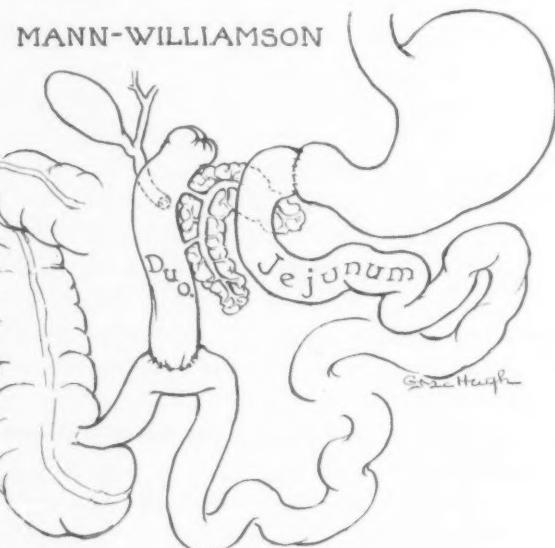
MANN-WILLIAMSON



FIG. 1.—Mann-Williamson procedure carried out in first group of animals.

A second man died of carcinomatosis six weeks after resection of the head and neck of the pancreas and at autopsy a benign ulcer with a sinus was found on the lesser curvature of the stomach. The reconstruction in this case consisted of a proximal posterior gastrojejunostomy, distal choledochojejunostomy and intermediate jejuno-jejunostomy. The transected stump of pancreas was ligated. There was failure of neutralization of gastric juice because of diversion of the bile and the absence of pancreatic juice.

The third patient had a resection of the head and neck of the pancreas for carcinoma of the head of the pancreas. A proximal gastroenterostomy, a distal cholecystenterostomy and choledochoenterostomy and an intermediate entero-enterostomy were performed. Closure of the pancreatic ducts was effected by
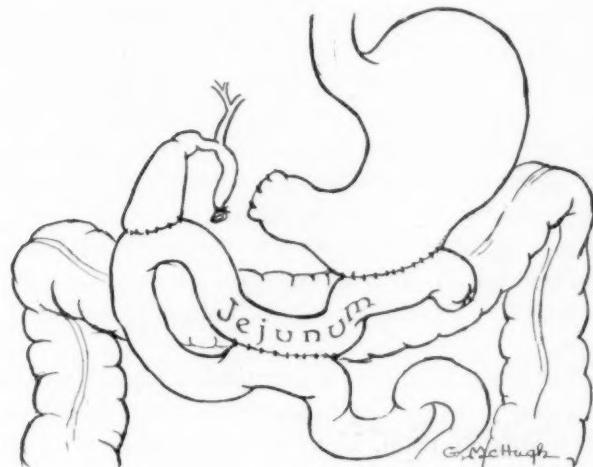
FIG. 2.—Reconstruction of gastro-intestinal tract following total pancreatoduodenectomy in Case No. 1.
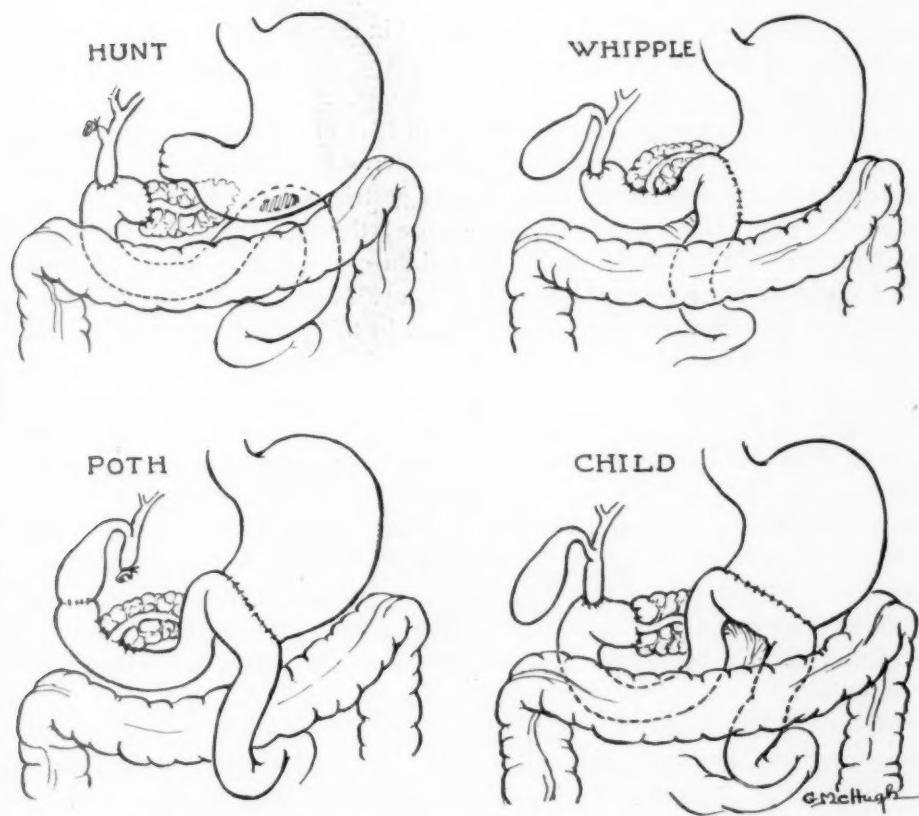


FIG. 3.—Methods of reconstruction which are founded on sound physiologic principles.

ligation and suture of the transected end of the pancreas. The patient made a satisfactory recovery from operation but returned a month later complaining of recurrent epigastric pain coming on about two or three hours after meals. Roentgen-ray examination of the upper gastro-intestinal tract failed to reveal any evidence of ulcer in the gastroenterostomy stoma, but there was a persistent collection of barium present along the lesser curvature of the stomach which was suspicious, but not a typical ulcer pattern. However, this patient responded well to a modified ulcer diet with the addition of magnesium and calcium carbonate powders. He has remained asymptomatic on a modified ulcer diet. The type of reconstruction in this instance resembled that employed in the other cases.

The methods of reconstructing the intestinal tract following the resection of the duodenum and pancreas are so numerous and varied that no attempt will be made to enumerate them. Many of these repairs tend to deprive the patient of the maximum neutralizing effect of the bile, pancreatic juice and duodenal secretions. So much attention has been paid to protecting the biliary passages against the reflux of intestinal content that the problem of protecting the gastroenterostomy has been largely ovelooked. The importance of implanting the pancreatic duct into the jejunum in case of partial pancreatectomy can be appreciated when one considers the strongle alkaline reaction of pancreatic juice.

The plan of repair published by Hunt[4] in 1941 has the advantage of affording the maximum protection to the gastroenterostomy stoma and at the same time reducing to a minimum the reflux of gastric and intestinal content into the bile ducts. Hunt (Fig. 3) anastomosed the pancreatic duct with the proximal end of the jejunum and implanted the common duct into the jejunum just distal to the pancreatodochojejunostomy. (Fig. 3). Somewhat farther distal was performed the gastroenterostomy. In this patient all of the bile and pancreatic juice passed the gastrojejunostomy site and maximum utilization of the neutralizing effect of these juices was obtained where it was most needed. Whipple[5] in 1943 and Child[6] and Poth[7] in 1944 have used methods similar to that described by Hunt. Child and Poth each removed the antrum of the stomach and made a Polya type of anastomosis. This avoided the blind pouch of stomach left by Hunt and Whipple and slightly reduced the acid secreting area of the stomach. The long jejunal loop made by Poth and Child affords protection to the biliary tree from reflux of gastric content. Waugh and Priestly have recently demonstrated a similar repair. Other methods of reconstruction fail to take full advantage of the protective action of bile and pancreatic juice.

Depriving the body of duodenal secretions by the resection of the duodenum reduces the neutralizing power of the alkaline secretions of the gastrointestinal tract. Undoubtedly this is a factor of less importance in cases of carcinoma of the pancreas than in benign lesions of the pancreas, for the gastric acidity tends to be reduced in those patients with carcinoma. However,

reconstruction after total or subtotal pancreatoduodenectomy in man should be done in such a manner as to neutralize the gastric juice as fully as possible. The ideal reconstruction operation consists of a choledochojejunostomy and, when a portion of the pancreas remains, a pancreatodochojejunostomy, both performed proximal to the gastrojejunostomy.

Pearse[8] has recently suggested standardizing the reconstruction following pancreatoduodenectomy. He considers the principles of repair to be:

1. The use of retrocolic end to side gastrojejunostomy.

2. The implantation of the common bile duct into the intestine.

3. The reconnection of the pancreas with the intestine.

4. The diversion of the gastro-intestinal contents away from the liver and pancreas by antiperistalsis.

We are in accord with his principles, but emphasize the fact that all bile and pancreatic juice should pass the gastrojejunostomy stoma.

The use of vagotomy in this operation to prevent the formation of ulcer has been considered. There are several objections. First, we feel that the basic repair, if properly done, should not require the added procedure of vagotomy. Second, experimental work done by Dragstedt and co-workers[9] with Mann-Williamson type of dogs reveals that vagotomy protects these dogs only slightly against the formation of ulcers. (46% of dogs with vagotomy developed ulcers, whereas 63% of dogs without vagotomy developed ulcers). Thus we feel that vagotomy is not indicated as an adjunct to pancreatoduodenectomy which in itself is a formidable operation.

## SUMMARY

1. The importance of the neutralizing effect of bile and pancreatic juice in the prevention of peptic ulcer is emphasized.

2. The development of peptic ulcers following improper reconstruction of the gastro-intestinal tract after pancreatoduodenectomy is cited. Three cases are reported.

3. Recommendations are made for methods of repair after pancreatoduodenectomy which make the greatest use of bile and prancreatic juice in the neutralization of acid gastric juice.

4. Vagotomy is not a substitute for the proper type of reconstructive procedure.

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# EXPERIMENTAL REPAIR OF COMMON DUCT DEFECTS UTILIZING A FREE VEIN GRAFT OVER BLAKEMORE-LORD TUBES *

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THE REPAIR OF COMMON DUCT DEFECTS and the treatment of stenosis of the common bile duct is an imposing surgical problem. Witness to this is the multitude of operative procedures which are employed today. Treatment of common duct stenosis is difficult in itself, becoming increasingly so when a defect of the duct must be bridged. Proportionally, the longer the defect which is present, the greater the difficulty in repair.

Eliot[1] in 1936 reviewed the various basic methods of repair of cicatrical strictures of the bile ducts which were in use from 1900 on. Many of the methods he discussed are still widely in use today. Two recent developments have contributed a substantial share of success in the treatment of these lesions. Pearse[2, 3] developed a vitallium tube for insertion in duct strictures to maintain patency. This method has been quite commonly used since his original publication in 1942. Cole et al[4] favor the modified hepaticojejunostomy with employment of the Roux loop and baffling of the intestinal wall, especially when a defect is present in the common duct. Pearse[3, 5, 6] in a report of 106 collected cases in which the vitallium tubes were used, makes note of the fact that each case in which the tube was used to bridge a gap in the duct resulted in failure. There were seven patients in the series in which this occurred. Pearse also states that the most desirable result is obtained only when and end-to-end anastomosis of the duct stumps can be carried out over a vitallium tube and the tube is left in situ indefinitely. Bettman,[7] Neibling and Walters,[11] and Cattell[12] have shown that biliary obstruction occasionally recurred with the use of the vitallium tube when it became plugged with deposit (bile encrustation), similar to that which occurred in rubber tubes which have been used for the same purpose.

Horsley, in discussing papers by Eliot[1] and Allen,[8] states that one of the earliest attempts in this country to reconstruct the common bile duct was performed by Sullivan in 1900 when he inserted a rubber tube into the hepatic duct and carried it into the duodenum. The indwelling tube was then surrounded with fat and neighboring tissue. Horsley, in 1918, inverted a segment of vein and sutured it into a defect which was made by resecting a portion of the common duct in dogs. He pointed out that the operation was successful from a technical standpoint, but after a few months the vein, being unaccustomed to irritation by bile, contracted and became completely obstructed.

* Submitted for publication, January 1948.

Dean Lewis, cited by Eliot,[1] related that experimental substitution of the wall of a vein, or other fascial structure, for the excised segment of duct invariably terminated in failure, and furthermore, that all plastic operations in which portions of adjacent hollow viscera were utilized for a similar purpose were unsuccessful and had been discontinued.
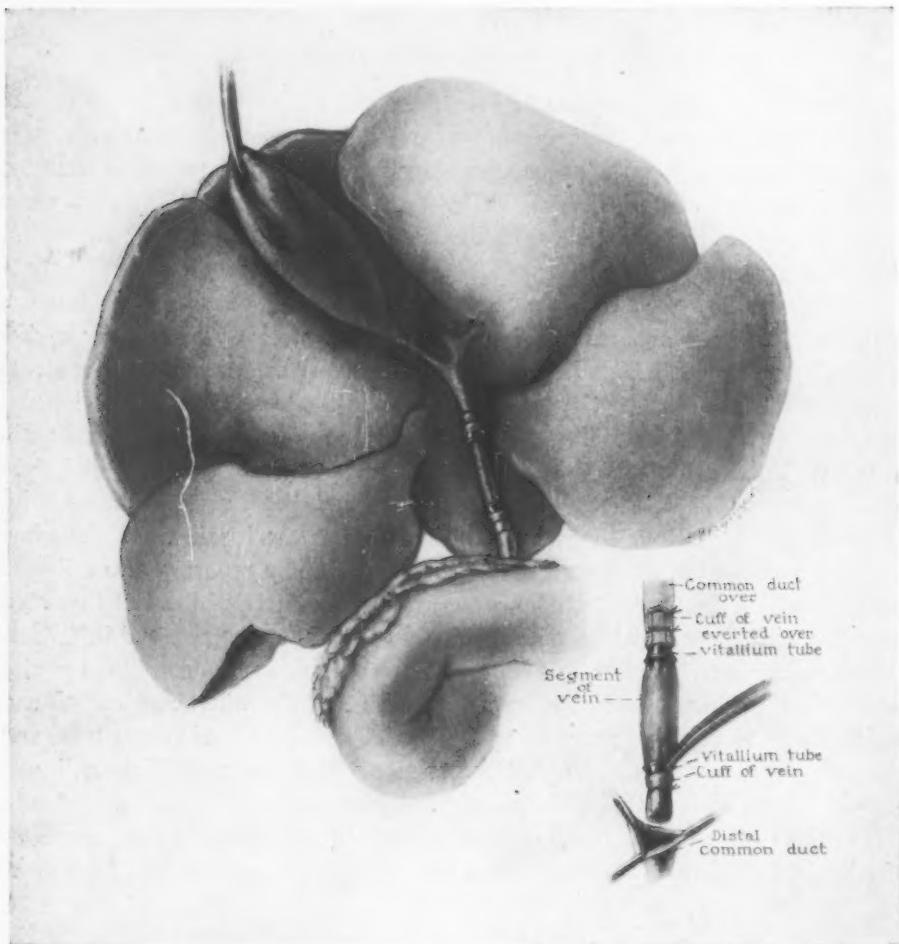


FIG. 1.—Experimental repair of defect of common duct in dogs, utilizing free vein graft and Vitallium tubes. Insert shows technic of implantation of vein graft in common duct.

Despite such adverse reports, however, Lord and Chenoweth[9] reported moderate success with the use of fascial and venous grafts over rigid vitallium tubes in the repair of common duct defects. In their experiments the fascial grafts proved most successful. They observed that the venous grafts developed a lining of biliary epithelium over the intima. Marked shrinkage in the length of their grafts occurred, however, and when the animals were sacrificed it was observed that none of the grafts was more than 3 mm. in length.

In the present experiments we are concerned with the repair of an artificially produced defect of the common duct in the dog. It would be ideal to use a pliable, non-irritant material or tissue which would be available in any length, and which would not be susceptible to necrosis or bile encrustation, and, preferably, one which necessitated the use of no suture material. It has been frequently shown that the presence of any of these factors is a definite detriment to the successful repair of a stenotic common duct or one in which a defect is present.

A non-suture method for anastomosis of blood vessels was described by Crile[13] in 1909. Hitchings, working in Crile's laboratory, devised a brass
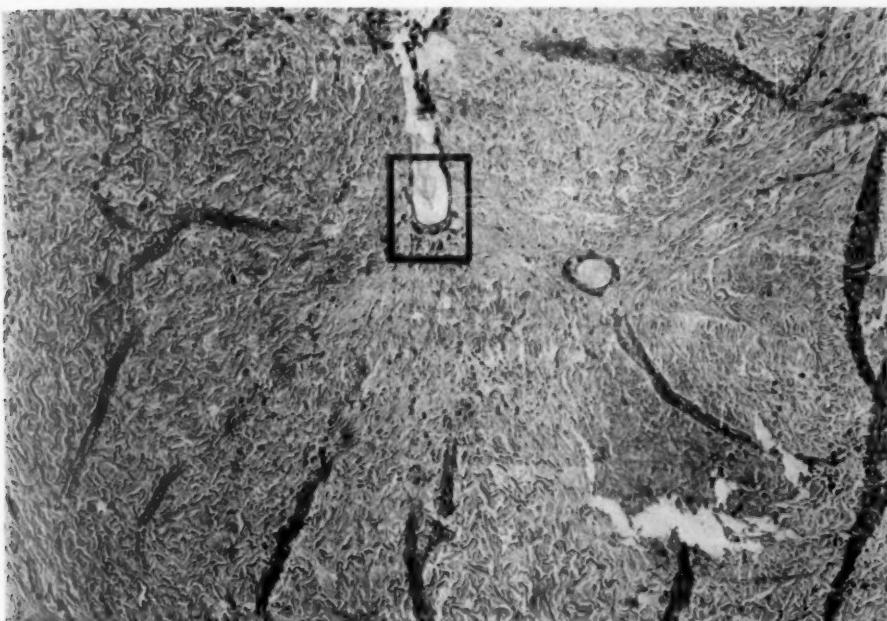


Fig. 2.—Photomicrograph (H & E stain). Free vein graft 88 days after implantation in common duct. There has been partial autolysis of biliary tract epithelium, but low columnar cells are evident in the outlined portion. Van Gieson stain shows the presence of normal elastic fibers. Trichrome stain reveals a normal amount of connective tissue. Cellular infiltration is absent.

cannula over which a vein was cuffed for insertion into an artery for direct transfusion of blood. Shortly after Blakemore and Lord[10] described in detail a non-suture technic for bridging arterial defects, employing special vitallium tubes of their own design, along with a free vein segment, it occurred to us that a defect in the common duct could be similarly bridged.

In contemplation of the problem we were well aware that difficulties such as Horsley encountered might occur. It was noted, however, that in employing this type of graft, no injury to duct epithelium or vein intima from the use of suture material would result, and therefore there would be less predilection to stenosis. Rather than invert the vein, we felt that the endothelium of the

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intima would withstand the irritation of bile far better than the adventitia, whose fibroblasts react more quickly to irritation. At the onset, it was also appreciated that several events might occur: first and most important, immediate necrosis and rupture of the vein graft might occur as a result of inadequate blood supply and irritation by bile; second, obstruction might result from edema of the vein wall or encrustation with bile salts; and third, fibrosis and ultimate stenosis might occur from irritation over a long period.

In its favor, however, the employment of the free vein graft over Blakemore-Lord tubes theoretically gave us an agent for bridging a gap in the common
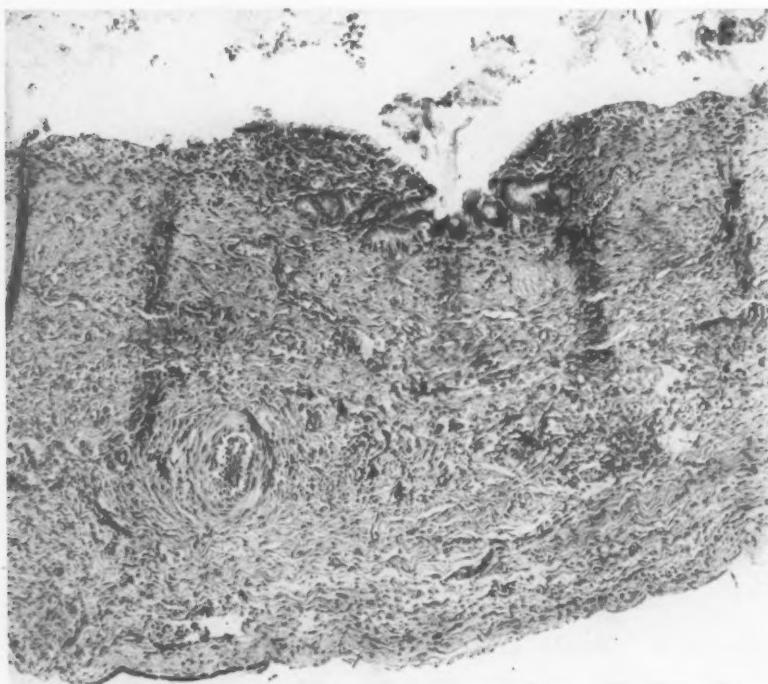


FIG. 3.—Photomicrograph (H & E stain). Bridging channel after free vein graft implantation of 114 days duration. H & E and PTAH stains show biliary tract epithelium lining the lumen. Van Gieson stain reveals the presence of elastic fibers and trichrome stain shows normal connective tissue. Cellular infiltration is absent.

duct which would obviate the use of suture material in the epithelial lining and which presented a medium of adequate length. Also, for all intents and purposes, it is a non-rigid system and one in which a common duct defect can be bridged and still retain the physiologic usefulness of the sphincter of Oddi. This is exceedingly important since ascending cholangitis is such a frequent complication of other types of repair.

We postulated also that there would be epithelialization of the intima of the vein segment with biliary tract epithelium, as reported by Lord and Chenoweth.[9] It was supposed that blood supply to the graft could only be

supplied by vascularization of connective tissue where the graft was interposed in the common duct and the ligature applied, and also from peritonization of the graft and surrounding area.

## METHOD

Mongrel dogs weighing 14 to 16 kg. were anesthetized with intravenous Nembutal, 1 cc. per 5 pounds of body weight. An intratracheal tube was introduced and intermittent positive pressure controlled respiration was
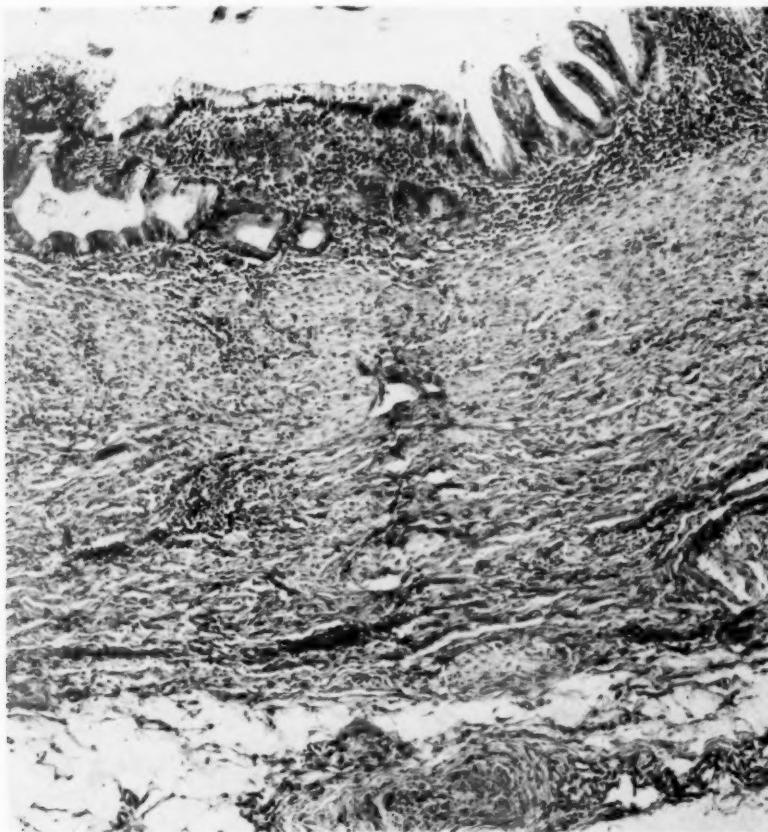


Fig. 4.—Photomicrograph (H & E stain). Bridging channel after free vein graft implantation of 208 days duration. This section, histologically, approaches the appearance of normal common duct seen in Figure 5.

maintained. Using aseptic precautions, a longitudinal incision was made in the left thigh from the knee to the inguinal fold over the femoral vein. The vein was dissected free from the surrounding tissue. All venous tributaries were ligated close to the wall of the vein with 4-0 Deknatel. In each experiment, a segment of vein 5 cm. in length or longer, depending upon the size of the animal, was utilized. Each end was ligated with 3-0 Deknatel and the vein segment excised. The vein segment was then cuffed over 3 mm. vitallium tubes after the method described by Blakemore and Lord[10] in the repair of

arterial injuries. The vein was secured to the tubes with 4-0 Deknatel and the prepared segment was irrigated with physiologic saline to determine its patency and placed in physiologic saline at room temperature. The thigh incision was closed in layers and continuous No. 38 stainless steel wire was used to approximate the skin edges.

A curved transverse incision was utilized to expose the right 9th rib, which was resected along with its cartilage. The thorax was entered through the rib bed and the diaphragm opened in the direction of its fibers. The intestines and stomach were packed away with moist tapes. The common bile duct was identified and mobilized for a distance of three to four cm. in its most distal portion. Two 3-0 Deknatel ligatures were then passed beneath the common
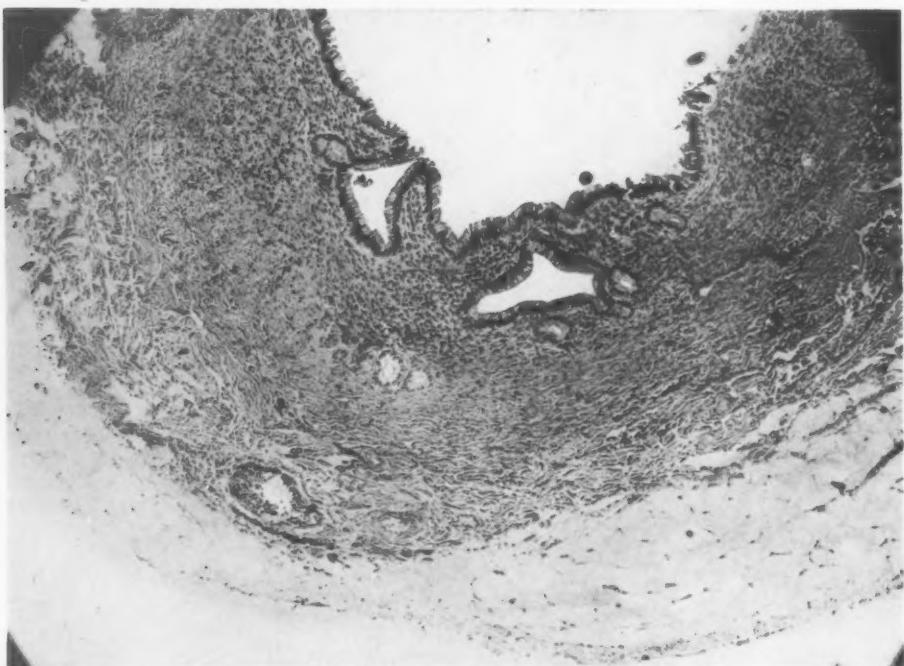


FIG. 5.—Photomicrograph (H & E stain). Histologic appearance of normal common duct of dog.

duct and the duct was then transected about 1.5 cm. for the duodenum, and with retraction of the duct ends, a defect 2 to 2.5 cm. in length was produced. The retracted ends of the duct were grasped with mosquito hemostats and triangulated. A curved hemostat was used to hold the free flange of the Blakemore-Lord tube, and the graft was introduced into the proximal end of the duct and secured with the previously placed ligature. An additional ligature was then placed proximally for security. A similar procedure was carried out in inserting and securing the graft in the distal portion of the duct (Fig. 1). In all instances a free flow of bile was observed at the distal end of the graft

before inserting it into the distal portion of the common duct. No attempt was made to bring omentum over the graft or to peritonize the operative site. The diaphragm was repaired with interrupted 3-0 Deknatel sutures and 100,000 units of penicillin were instilled into the pleural cavity after the partially collapsed lung was re-expanded. The skin was closed with continuous No. 38 stainless steel wire suture which was left in situ throughout the experimental period.

This particular operative approach was found to result in the most satisfactory exposure of the extrahepatic biliary system in the dog. The common duct of dogs of this weight is 3 mm. or less in diameter. In our total series there were no operative deaths.

It must be noted that in our earliest procedures we observed that a short segment of vein retracted in such a fashion as to cause over-riding of the

TABLE I.—*Experimental Data*

| No. of Dogs | Experimental Period (Days) | Patent Grafts | Ruptured Grafts | Visible Graft with Obstruction |
|---|---|---|---|---|
| 9 | 5-26 | 6 | 2 | 1 (a) |
| 5 | 34-57 | 3 (b) | 0 | 2 (c) |
| 2 (d) | 68-88 | 1 | 0 | 1 |
| 4 | 104-114 | 4 | 0 | 0 |
| 1 | 208 | 1 | 0 | 0 |
| Total 21 | | 15 | 2 | 4 |

(a) In one animal there was partial obstruction, although bile could be expressed through the system from the gallbladder with gentle pressure.

(b) One animal sacrificed at 56 days, another at 57 days. Vein graft was unidentifiable but patent channel was present and bile flowed freely into the duodenum.

(c) One animal was normal until 36 days after operation when jaundice appeared. At autopsy, seven days later, the vein graft was obstructed due to swelling at the proximal tube, but had remained elastic and viable.

(d) Both vein grafts were intact, viable and elastic. One animal became jaundiced and at autopsy dilatation of the common duct proximal to the graft was observed, due to swelling of the graft within the proximal tube.

flanges of the vitallium tubes and a resulting mechanical biliary obstruction. To obviate this, tubes with smaller flanges were used with success. With larger defects to bridge, and with the utilization of longer vein segments, this complication was absent.

### RESULTS

Twenty-one dogs comprise this series and in each a vein graft over Blakemore-Lord vitallium tubes was used to repair a defect of the common duct. Autopsy was performed on all the animals at death or when sacrificed at the end of the experimental period. In each case the extrahepatic duct with the graft in situ was tested for patency by gently perfusing the common duct proximal to the graft with physiologic saline and observing whether the perfusion fluid flowed readily from the ampulla of Vater. At autopsy it was noted that in all dogs that had survived an experimental period of 10 days or more, the previously denuded site of operation and the graft itself were completely covered by peritoneum.

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The results are grouped in Table I, according to the experimental period in which the graft was in situ.

In the total series, there were four animals which we considered failures. Early in the series two animals developed absolute biliary obstruction due to swelling of the vein graft within the proximal vitallium tube which in these instances was of 2 mm. size. One dog died as a result of necrosis and rupture of the graft when one vitallium tube became kinked upon the other. The fourth animal developed necrosis and rupture of the graft, along with acute suppurative peritonitis, concomitant with distemper.

We can only consider the result as equivocal in three of the animals. In two instances death occurred as a result of severe distemper on the 16th and 22nd postoperative days, respectively, and it was felt that this experimental period was inadequate. We did observe, however, that these two animals had patent and viable vein grafts, although one showed slight dilatation of the proximal biliary tract. Bile expressed from the gall bladder, however, flowed freely from the ampulla of Vater. A third animal survived 88 days; on the

TABLE II.—*Experimental Results*

| No. of Dogs | Excellent | Equivocal | Failures | Per Cent |
|---|---|---|---|---|
| 21 | 14 | | | 66.7 |
| | | 3 | | 14.3 |
| | | | 4 | 19.0 |

68th postoperative day this animal developed severe distemper followed by profound jaundice. At autopsy there was severe swelling and obstruction of the graft at the proximal vitallium tube.

Fourteen animals lived 10 to 208 days before being sacrificed. In each, at autopsy, there was a patent channel between hepatic ducts and duodenum.

Nine of these 14 animals still utilized the original free vein graft (Fig. 2). The remaining five animals developed a patent, pliable channel lined with biliary epithelium. The vein segment, in the meantime, had lost its identity and contiguity in the fibrous growth. (Figs. 3, 4.)

### SUMMARY

A series of 21 animals is presented (Table II) in which a common duct defect was repaired with a free vein graft over Blakemore-Lord tubes. In 14, or 66.7 per cent, of these animals, the resulting bridging channels remained functionally patent and a free flow of bile was maintained. Three, 14.3 per cent, developed severe distemper and the experimental period was considered inadequate, although the vein graft remained viable and elastic. Four, 19 per cent, were described as failures and a discussion of each is presented.

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# CONSERVATIVE THERAPY OF RESIDUAL CALCULI FOLLOWING OPERATIONS ON THE COMMON BILE DUCT\*

## Report of Two Cases

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RESIDUAL CALCULI are occasionally observed in the common bile duct following operations upon it. Formerly, surgical exploration was required for the removal of these stones. Within the past ten years, however, reports have appeared in the literature concerning the fragmentation and dissolution of these stones by chemical means through the "T" tube indwelling in the common duct. Pribram[1] has reported 38 cases of common duct stone which were cured by the installation of ether and liquid paraffin. He states that a secondary operation was not required in this type of case for at least seven years. He considers that a secondary operation be indicated only if thorough and long therapy with the ether-paraffin has failed. His cases required a maximum of six weeks treatment prior to disappearance of the stones. Walters[2] and Burgess[3] report excellent results in similar patients in whom the Pribram method of treatment was supplemented with the use of nitrites, in order to relax the papillary sphincter. Other investigators have reported success with various solvents such as chloroform[4] and solution "G",[5] and in some cases[6] nupercaine has been used successfully.

It is imperative to relieve the obstruction produced by calculi in the biliary tract. When a "T" tube remains in the common duct, however, it is uncommon to have evidence of liver damage or other sequellae of common bile duct obstruction. Conservative management of such cases would be particularly indicated. In the cases reported below, a trial of conservative therapy for three months in one patient, and for eleven months in the other, resulted in complete disappearance of the stones. Freedom from symptoms followed removal of the "T" tube in each case.

## CASE REPORTS

**Case 1.** S. D., white male, age 38, was admitted to the medical service of Dr. H. Goldburgh, at the Jewish Hospital, Philadelphia, on October 22, 1945. His chief complaint was abdominal pain and colic of five days duration, which had been followed, after 24 hours, by increasing jaundice, anorexia, and nausea. No vomiting was experienced. Stools were acholic. There was a previous attack of pain and jaundice in 1944, one year preceding this present episode. On admission, the patient presented moderate pallor and severe jaundice. There was marked muscle guarding in the right upper quadrant of the abdomen. No mass was palpable and no tenderness was present.

Laboratory studies revealed a hemoglobin of 16.5 gm., red blood cell count of 5.1 million per cu. mm., white blood cell count of 8.2 thousand per cu. mm., with a normal differential picture. Urine had a pH of 5.0, specific gravity of 1.013 to 1.024, bile and

\* Submitted for publication, January 1948.

urobilinogen were present. Bile pigment was identified in the feces. Blood sugar was 88 mg. per cent; blood urea nitrogen was 15 mg. per cent; and the blood cholesterol was 286 mg. per cent with 70 per cent esterification. Prothrombin time was 125 per cent of normal. Serum amylase was 86 units. Icterus index was 38 units on admission, and it fluctuated from 28 to 42 units during the preoperative course.

After adequate preparation, the patient was transferred to the surgical service of Dr. F. B. Block. Operation was performed November 3, 1945. The abdomen was opened through a right rectus incision. The gallbladder contained stones. The common bile duct was filled with a creamy, inspissated material, but a calculus was not demonstrated in the common duct. The gallbladder was removed and a "T" tube placed into the common bile duct.

Postoperative convalescence was uneventful. On the eleventh postoperative day a cholangiogram indicated that dye was not passing into the duodenum. At that time, the duct was lavaged through the "T" tube with 3 - 4 cc. of ether. This was repeated daily,



A                                                   B
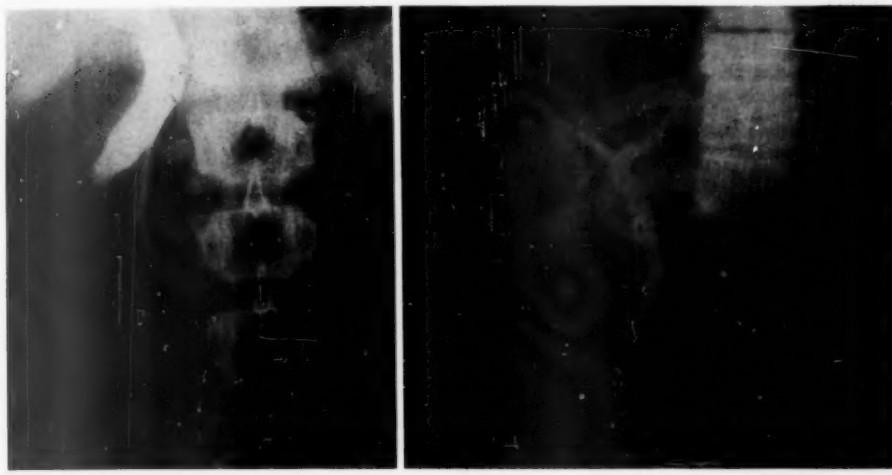
FIG. 1A.—*Patient S.D. Before Ether Therapy.* Notice tremendous dilatation of common bile duct and radiolucent defect at distal end of duct. No flow of diodrast into the duodenum is seen.

FIG. 1B.—*Patient S.D. After Ether Therapy.* Duct now normal size. Radiolucent defects gone. Free flow of contrast medium into the duodenum is evident.

usually without discomfort to the patient. If pain appeared, inhalation of amyl nitrite was sufficient to control it. Repeated cholangiograms were done on November 20 and 27, 1945. These indicated a calculous obstruction at the distal end of the common bile duct, associated with retrograde dilatation of the common and hepatic ducts. (Figure 1a) Dye did not pass into the duodenum during the roentgen study. On several occasions, solution "G," instead of ether, was used to perfuse the duct, but the patient did not tolerate this material.

During this period, the patient's icterus index returned to normal values. Repeated tests of liver function were returned at normal levels. The patient was discharged from the hospital on November 27, 1945, with the "T" tube left in place. He had been instructed in the management of the irrigations of the common bile duct using the ether injection. This was continued daily while the patient was at home.

Two months later, on January 9, 1946, a cholangiogram revealed that there was free flow of the contrast medium into the duodenum. The biliary ducts were minimally dilated, and there was no longer any evidence of calculous obstruction at the distal portion of the common bile duct. (Fig. 1b) In view of the fact that this patient had been asymptomatic for five weeks, the "T" tube was removed.

This patient has remained well. Follow-up examinations have shown absence of jaundice or pain, and complete freedom from any complaints referable to the biliary or gastro-intestinal tract, for 18 months since the removal of the "T" tube.

**Case** 2. F. K., white female, age 54, was admitted to the Surgical service of Dr. F. B. Block, at the Jewish Hospital, on October 1, 1946. Her chief complaint was severe colicky abdominal pain, accompanied by indigestion of 36 hours duration. The pain, which originated in the right upper quadrant, radiated under both costal margins.



A           B
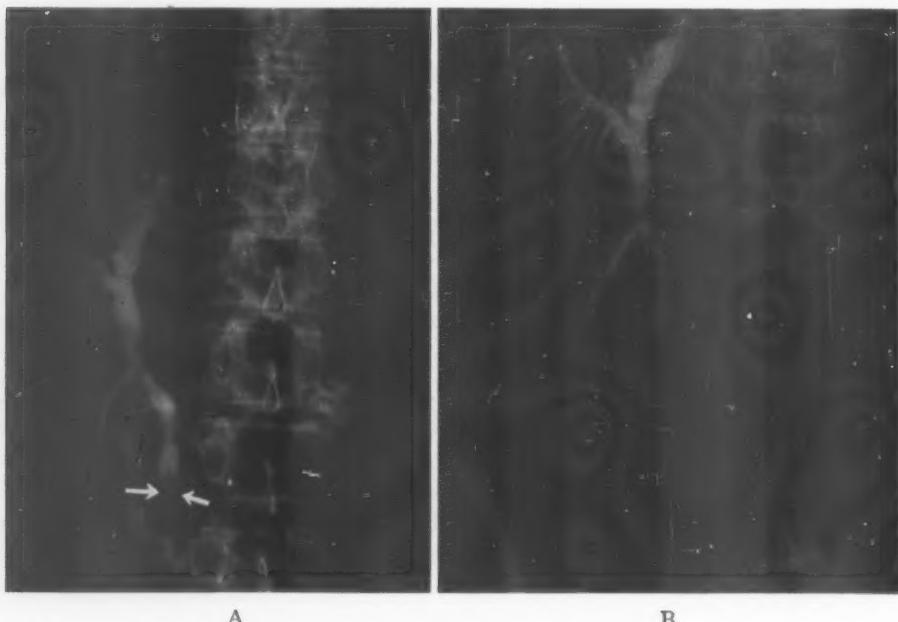
Fig. 2A.—*Patient F.K. Before Ether Therapy.* Common duct somewhat dilated. Radiolucent defects indicating stones at distal end of common bile duct (between arrows). Obstruction is not complete, as evidenced by the presence of the contrast medium in the small intestine.

Fig. 2B.—*Patient F.K. After Ether Therapy.* Radiolucent defects not present. Common duct not dilated. Diodrast present in duodenum.

There was no nausea or vomiting. Stools were normal in character and appearance. On examination this middle aged woman looked acutely ill. Her abdomen was moderately obese. Marked tenderness and rigidity were found in the right upper quadrant. A tender mass in the right subcostal region, difficult to outline, was interpreted as enlarged gall-bladder. No jaundice was noted. Peristalsis was normal. A cystocele and rectocele were discovered as incidental findings.

Laboratory studies indicated the hemoglobin to be 13.7 Gm., and the white blood cell count was 20,600 per cu. mm., with 91 per cent polymorphonuclear cells. Urine had a pH of 6.0, specific gravity of 1.010; there was no sugar, albumen, or bile present. Urobilinogen was present in the urine in 1:20 dilution. Blood icteric index was 20 units,

TABLE I.—*Intra-choledochal pressure readings (Case Two)*

| Date | Initial Pressure (cm H20) | During increasing amounts of solution (all in cm of water) | | | | Pain Threshold (cm of H20) | Vol. in duct (cc.) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | 5 cc. | 10 cc. | 20 cc. | Highest pressure | | | |
| 5/11 | 6 | 15 | 30 | — | 32 | 30 | 11 | 150 cc. of solution; sluggish flow; tiny mucoid particles in return flow. |
| 5/12 | 4 | | | 30 | 30 | | 15 | 450 cc. of solution; severe pain followed; pigment debris present. |
| 5/15 | 0 | 8 | 17 | 25 | 25 | | 5 | 500 cc. of solution at 30 cm. of water press. Residual fluid clear; free flow. |
| 5/16 | 0 | | | 26 | 26 | 26 | 11 | 250 cc. of solution at 40 cm. of water pressure residual fluid clear; free flow. |
| 5/17 | 0 | 10 | | 20 | 32 | 20 | 14 | 200 cc. of solution at 50 cm. of water pressure. Residual fluid clear; free flow. |
| 5/19 | 0 | | | | 28 | 28 | 0 | 300 cc. of solution at 60 cm. of water pressure. Residual fluid clear; free flow. |

and the blood serum amylase was 455 units. Blood sugar, urea nitrogen and serologic examinations were normal.

A diagnosis of acute pancreatitis associated with cholelithiasis was made presumptively. This patient was treated conservatively. She was given oral and parenteral feedings of proteins and carbohydrates reinforced with adequate vitaminotherapy. Her clinical status improved rapidly. After one week, the icterus index was 6 units, and the blood amylase had decreased to 83 units. With subsidence of the acute episode, a cholecystogram was done. This revealed marked decrease in gallbladder function. Bromosulfalein test for liver function revealed that no dye was retained in the blood stream at the end of 45 minutes.

Operation was performed on October 12, 1946. The abdomen was opened through a right rectus incision. Exploration was limited to the gallbladder, common bile duct, and immediately adjacent tissues. There was marked edema of the area about the cystic duct and the ampulla of the gallbladder. Adequate dissection of this region was prohibited by the extent of the inflammatory process. The common duct was opened, and approximately eight small facetted stones were removed. Irrigation of the duct returned clear fluid, and there was no interference of flow of the irrigating fluid into the duodenum. A "T" tube was sewn into the common bile duct. A partial cholecystectomy was done. The gallbladder bed was drained.

Examination of the gallbladder revealed beginning gangrene of the mucosa, with evidence of chronic cholecystitis. Multiple facetted calculi were present in that organ. On section, these calculi were composed of an outer brittle layer of white material and a soft pigmented nucleus. The outer shell was fragmented rapidly, and partially dissolved within ten minutes of the stone's immersion in ether.

The patient's postoperative course was normal. She was ambulant on and after her first postoperative day. Oral intake was sufficient and the patient generally comfortable. Stools were normal in color and no icterus was present. The "T" tube was clamped on the 10th postoperative day, without clinical signs or symptoms.

A cholangiogram was done on October 25, the 13th postoperative day. A radiolucent shadow was noted in the terminal portion of the common bile duct, and several shadows which resembled calculi were noted in the hepatic duct radicles. Three to four cc. of ether were injected daily thereafter through the "T" tube. The injections produced moderate discomfort.

Cholangiogram was repeated on October 29, 1946, at which time diodrast passed from the common duct into the duodenum. A persistent dilatation of the common and hepatic ducts was visualized. Radiolucent defects were present at the distal end of the common duct and in the hepatic duct proximal to the hepatic limb of the "T" tube. (Fig. 2a)

The patient was instructed to irrigate the long limb of the "T" tube once to twice daily with three to four cc. of ether. She was discharged from the hospital on November 1, 1946, but returned on November 9, 1946, because of recurrent colicky pain which accompanied perfusions of the duct. During this admission, physical examination revealed no jaundice, mass, fever, or any physical abnormalities. A cholangiogram showed that the shadows previously reported were less numerous and had moved to a more distal position in the ducts. In addition, the cholangiogram revealed that there was less dilatation of the hepatic ducts.

She was discharged after four days observation with instructions to irrigate the tube as before. It was the clinical impression that the lavage was inducing fragmentation of the calculi, and that her episodes of pain were due to small pieces passing through the papilla of Vater. She was advised to inhale amyl nitrite should any of these episodes become distressing.

These irrigations were continued for three weeks until December, 1946, after which the irrigations were done two to four times weekly. On several occasions she suffered

mild colic or indigestion, but without disability of more than a few hours.

On May 11, 1947, the patient was readmitted to the service of Dr. F. B. Block for repair of the cystocele and rectocele. During this admission a cholangiogram revealed that a radiolucent shadow resembling a stone was present in the papillary area of the common bile duct.

The duct volume and intraductal pressures were measured on several occasions. (Table I.) The volume of fluid contained in the common bile duct varied from eight to 15 cc. This indicated that the duct was now of normal size. Pressure readings were generally normal, since pain appeared at 30 cm. of water, and the duct emptied at 20 to 32 cm. of water.

Pressure studies were also used as therapy. During each succeeding installation of perfusing fluid, pressure levels were increased progressively in an attempt to increase the fragmentation of the residual calculus, and to permit passage of debris through the papilla. Initially, 10 cc. of 1% metycaine solution was used prior to the installation of any perfusing fluid. Subsequently, all procedures were accomplished with 0.1% novo-caine in normal saline. A maximum of 500 cc. of solution was perfused at any one time. The basis for this therapy was a recent report[6] and previous successful experiences by one of the authors (JAS).

At all times perfusing fluid entered the duodenum. During earlier tests, there was marked resistance to flow; and moderately severe discomfort was suffered by the patient. Following the procedure on May 12, 1947, and its attendant severe colic of three hours duration, all other procedures were easily tolerated. At no time, thereafter, was any obstruction encountered to the irrigations.

Despite clinical evidence of the free flow of bile, and of the normal volumes in the common bile duct, cholangiogram revealed that the radiolucent shadow persisted in the papillary region of the common bile duct. No evidence of dilatation of the biliary radicles was present.

The patient was discharged from the hospital on May 25, 1947, following full con-valescence from the vaginal plastic operation. The "T" tube remained in position and was irrigated several times weekly with ether for the next three weeks. After this period, the "T" tube was clamped shut continuously.

After several months of complete freedom from all symptoms, a cholangiogram was performed on September 10, 1947. At this time, there was uninterrupted flow of diodrast into the duodenum, and no evidence of calculi. (Fig. 2b)

The "T" tube was removed on September 17, 1947, 26 days short of one year since its insertion. The tube was encrusted with bile stained and inspissated putty-like debris. The sinus drained but a few drops of bile stained mucoid material for 24 hours. The wound has been completely dry since then. There have been no signs or symptoms of biliary tract or gastro-intestinal tract disturbance and the patient is completely comfortable more than ten months after the removal of the tube.

### DISCUSSION

The literature contains several case reports of success in the conservative management of residual choledocholithiasis following operations on the common bile duct. These stones may not have been observed, or may have been inaccessible at the time of the operation.

Such calculi can produce total obstruction to bile flow, although the obstructive phenomena are usually incomplete and intermittent. Some stones may disappear spontaneously through disintegration, or pass into the gastro-intestinal tract through the papilla of Vater or through an artificial fistula. Others may[7] become imbedded in the wall of the papilla, as in a diverticulum of the duct. Some stones can remain as asymptomatic foreign bodies.

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The usual indications for surgical removal of such residual calculi in the common bile duct are:

(1) complete biliary tract obstruction with progressive jaundice.

(2) recurrent pancreatitis.

(3) advancing liver dramage.

(4) recurrent suppurative cholangitis.

It is advisable to avoid secondary procedures on the biliary tract since the risk of reoperation is great and because the technical procedure is frequently very difficult.

It is felt that surgical intervention can be delayed in those patients in whom biliary flow is adequate, and in whom liver function is not impaired. It is similarly thought that conservative management is advisable in patients who are symptomatically comfortable, and who do not present evidence of gross infection. Lavage of the common bile duct through an indwelling "T" tube can be expected to produce excellent results in the therapy of residual choledocholithiasis, if given a trial for a sufficient time.

It should be noted that ether boils at body temperature. This phenomenon is the usual cause for patient discomfort, since the expanded vapours can exert considerable pressure. This in itself is an added advantage because of an increasing pressure increment thus introduced. It is recommended that only three to four cc. of ether be instilled in the common duct during the initial perfusions. If discomfort occurs, the syringe may be disengaged and the ether permitted to bubble out of the open end of the "T" tube. Nitrites may be administered for relief of pain, or prior to the injection in order to relax sphinteric action at the termination of the common bile duct.

### SUMMARY

Two patients who were treated surgically by cholecystectomy and choledochostomy for calculous disease of the biliary tract were found to have calculi remaining in the common duct postoperatively. In one case, daily instillations of ether during a two-month period were followed by the disappearance of the stone. In the second case, instillations of ether were continued for seven months. In addition, lavage of the duct was done on occasions, using novacaine solutions under increasing intraductal pressure. In this case, stones were not present in the common duct eleven months after their initial recognition. Following the removal of their "T" tubes, both patients have remained asymptomatic.

It is recommended that conservatism be used in similar cases whenever possible because of the technical difficulties of reoperation and the greater risk to the patient. It is also recommended that gall stones removed at operation be saved, and tested for solubility in ether and other solvents, in the event that this information is required in the treatment of the complication of residual common duct stones.

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# BLOOD FAT LEVELS FOLLOWING SUPRADIAPHRAGMATIC LIGATION OF THE THORACIC DUCT

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CONSIDERING THE GREAT VARIATIONS in anatomic configuration and relationships of the human thoracic duct, [2, 3, 9] inadvertent severing of this structure during the course of surgical procedures in the supradiaphragmatic region appears to be a relatively uncommon accident, rarely occurring more than once or twice in the experience of any one surgeon. With the ever-growing frequency of extra- and intrapleural operations, however, there is reason to anticipate that the number of such accidents will increase.

The flow of chyle in the thoracic duct may be interrupted in one of two ways, i.e., by section or ligation. Instances in which the duct has been severed have been more frequently reported in the literature than those in which it has been ligated. Its section results in chylothorax, a complication regularly attended by considerable morbidity in the form of asthenia, inanition and progressive emaciation and not infrequently terminating fatally (1, 5, 13, 14). In a review of the literature up to 1937, Shakelford and Fisher reported an over-all mortality of approximately 50 per cent. Surgical ligation of the duct, on the other hand, does not result in chylothorax and for this reason is attended by a much less severe morbidity than severance.

Both accidents afford unusual opportunities for furthering our understanding of the role of chyle in human bodily economy. Unfortunately, advantage of such accidents has not always been seized by clinicians, so that there remain as yet many obscurities in our understanding of the physiology and pathology of chyle that might otherwise have been illuminated. In view of this, it appears desirable that increments to our knowledge, whether great or small and whether or not documented by oft-repeated observations, should be communicated as they become available.

Of the human studies thus far recorded, the majority have been made in connection with chylothorax, attention having been focused mainly upon the chyle recovered from the chest cavity rather than upon the altered biochemistry of the blood and other bodily fluids. The data acquired permit a fair estimate of the quantity of chyle produced under conditions of chylothorax, namely, 130 to 200 cc. per hour. Certain physical and chemical characteristics of the recovered chyle have also been determined—its alkaline reaction, specific gravity between 1.012 to 1.020, total fats between 0.5 to 3.0 Gm. per cent, total proteins between 1.0 to 6.0 Gm. per cent, and an albumin-globulin ratio of 3:1.[5, 9, 14]

* Submitted for publication, January 1948.

The concomitant alteration of blood constituents in the presence of chylothorax has been less frequently an object of inquiry. There is, however, strong indication that within 24 hours of the establishment of chlothorax or chyloperitoneum the blood fats are diminished by approximately 25 per cent of their normal levels and the plasma proteins are reduced to a small but perceptible degree.[5, 7, 15] Beyond the first 24 hours, the plasma proteins have been observed to fall steadily to such an extent that within two to three weeks they reach levels as low as 3.8 Gm. per cent.[15] Finally, it has been established for the human (as for other mammals) that the absolute and relative quantities of chyle and its several constituents vary in a fairly direct fashion with the proportions of water, proteins, fats and carbohydrates in the diet.[7]

The present writers recently encountered a patient in whom the main thoracic duct was inadvertently ligated and severed during the course of supradiaphragmatic splanchnicectomy and sympathetic chain resection for essential hypertension. Following the accident, alterations in the patient's blood fat level were followed until homeostatic conditions in respect of blood fat were regained. So far as has been possible to ascertain by an inquiry into the literature, no similar study has thus far been recorded.

### REPORT OF CASE

A negress of 28 years was admitted to the University Hospitals on November 14, 1946, complaining of fronto-occipital headaches, "nervousness," giddy spells, cardiac palpitation, dyspnea, chest pains, insomnia and blurred vision. These symptoms had been irregular in their severity but generally progressive for a period of four to five years. During the two months prior to the patient's hospitalization, she lost 20 pounds' weight.

The family, social and past medical histories disclosed nothing remarkable. The patient had had three pregnancies, all of which were successfully terminated, the most recent three years prior to hospitalization. Her menses had been normally reestablished following delivery and had remained so during the intervening years.

Physical examination disclosed an affable, intelligent and well nourished negress of athletic habitus. Her rectal temperature was 99°F., pulse rate 80 per minute, respiratory rate 16 per minute and brachial blood pressure 190/125 mm. Hg. Nothing unusual was revealed by examination of the head and neck. There were no evidences of hypertensive retinopathy. A soft, blowing, systolic murmur was audible at the apex. The heart was not enlarged and no findings suggestive of cardiac decompensation were disclosed. Clinical examination of the thorax, abdomen, pelvis and rectum yielded no other significant findings. The radial pulses were strong and difficult to compress but the peripheral vessels of the upper and lower extremities yielded no clinical evidence of sclerosis or tortuosity.

The clinical work-up was carried out in accord with the schema routinely employed in the pre-operative study of hypertensive patients.[10, 11] The blood pressure was recorded at regular intervals throughout a period of 24 hours, under waking conditions and those of spontaneous and induced sleep. It proved highly labile, ranging between 230/130 and 130/85 mm. Hg. The urine analysis, concentration of the urine, red and white blood cell counts and sedimentation rates revealed nothing unusual and the blood Wassermann test was negative. The blood cholesterol was recorded at 142 mg., the blood urea nitrogen at 15.0 mg. and the blood creatinine at 1.0 mg. per cent. Determinations of the basal metabolic rate were within normal limits on two occasions. The electrocardiogram revealed a left axis deviation, a positive P-wave in Lead 4, a positive T-wave in Leads 1 and 2, and a negative T-wave in Lead 4. These findings were considered sugges-

tive of a mild degree of cardiac muscle damage. A six-foot plate of the chest demonstrated clear lung fields and a Danzer Ratio of 0.49. The intravenous pyelograms were considered normal.

A diagnosis of essential hypertension was made and the patient was considered a suitable candidate for surgery.

*Operation, December 4, 1946:* General anesthesia was induced under endotracheal nitrous oxide inhalation and maintained by the intravenous administration of pentothal sodium. A 7 cm. segment of the right tenth rib was resected. Its head was distarticulated and the corresponding transverse process removed by the rongeur. A plane of cleavage between the parietal pleura and chest wall was developed. The pleura was then retracted so as to give access to the sympathetic chain from the eighth dorsal to the first lumbar paravertebral ganglia. These ganglia and the intervening segments of the chain were
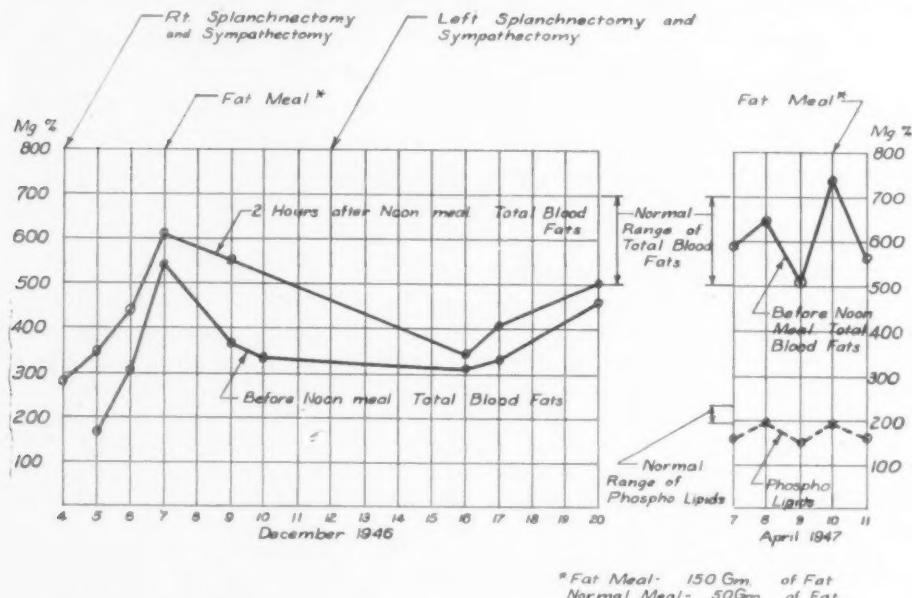


FIG. 1.—Graph showing postoperative levels of blood fat and phospholipids.

ligated and removed. During the ensuing exploration a structure regarded as the greater splanchnic nerve was encountered. A one-inch segment was doubly ligated with black silk and transected between ligatures, whereupon a droplet or two of chyle exuded from the cut end, leaving no doubt as to the structure attacked. The distal portion of the ligated duct immediately began to swell and soon attained a diameter slightly greater than that of a common lead pencil. The splanchnic nerves were subsequently identified somewhat closer to the midline than ordinarily encountered. They were doubly ligated and a segment approximately one inch in length was removed from each. A silk "sleeve" was secured over the proximal stumps. The operator had quite evidently mistaken the thoracic duct for the greater splanchnic nerve.

The patient's postoperative course was uneventful. Symptomatically, she offered no complaints other than of "soreness" at the operative site. To all objective clinical examinations she appeared normal.

Within three hours of the ligation of the thoracic duct and before the ingestion of food, the total blood fat level was 280 mg. per cent. On each of the ensuing three days, total blood fat determinations were made immediately preceding and again two hours

following the noon-day meal. These data* demonstrated a marked reduction of blood fat levels below the normal range of 500-700 mg. per cent (See Fig. 1).

On December 7th, the third day following operation, a high-fat diet of 150 Gm. was given the patient in order to ascertain its effect on the blood fats. The total blood fats—both before and after the noon-day meal—were discovered to be just within the lower limits of normal range.

Further determinations of blood fat levels under ordinary dietary conditions were resumed on the following day and repeated at intervals up to the sixteenth postoperative day. They continued at subnormal levels but there was observable a gradual trend in the direction of normal.

Splanchnicectomy and sympathetic ganglionectomy were carried out on the opposite (left) side on December 12, 1946, this time without untoward incident. The patient made an uneventful recovery and was discharged from the hospital on the ninth postoperative day.

In order to afford a degree of assurance that the data obtained in the case above reported are not generally characterictic of hypertensive patients of the type who qualify for sympathetic surgery in accord with our criteria, three patients (E. R., female, and K. S. and F. J. males) were subjected to preoperative determinations of total blood fats and phospholipids. Postoperative determinations were made at the 24th, 48th, and 72nd hours and thereafter every other day, the last specimens being drawn on the seventh postoperative day. In none of these were the levels of blood fats or phospholipids found to deviate from the accepted ranges of normal. In this group of subjects, the lowest recorded blood fat level was 500 mg., the highest 780 and the mean, 615 mg. per cent. The lowest recorded phospholipid level was 184 mg., the highest 300 mg. and the mean, 225 mg. per cent.

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* The methods employed for the determination of total fats and phospholipids in the present study are those devised by Gibson, Lowe and Morrissey (unpublished).

For determination of total fat, 5 cc. of plasma or whole blood is mixed with 25-30 cc. of 90% alcohol. The total mixture is swirled slowly within a 125 cc. Erlenmeyer flask. The flask is heated in a steam bath for 10 minutes and is then allowed to cool. Sixty cc. of diethyl ether are then added. The liquid is filtered through a funnel plugged with fat-free cotton into an evaporating dish. The flask is washed out with several portions of ether and the liquid is pressed out of the solid mass in the funnel with a glass rod. The filtrate is evaporated on a steam bath, care being exercised not to heat the dish once drying has been accomplished. The fat is now dissolved out with several 10 cc. portions of petroleum ether, each portion being evaporated to a volume of approximately 5 cc. The liquid is now filtered through a small, fat-free filter paper into a weighed dish and evaporated on the steam bath. The dish is kept in a vacuum dessicator for 20 minutes and is then weighed. Calculations: Gain in weight $\times$ 20 = mg. per cent of total fat. The normal value in plasma by this test is from 500 to 700 mg. per cent.

For determination of phospholipids, the fats are washed into a 125 cc. Erlenmeyer flask with several 2 cc. portions of petroleum ether. The liquid is then swirled slowly while 3 volumes of acetone and 3 drops of saturated magnesium chloride solution in 95% alcohol are added. The solution is placed in the icebox for 15 to 30 minutes, during which time the phospholipids flocculate. The mixture is now filtered into the weighed dish referred to above. The flask is carefully washed with several portions of acetone, the washings being poured through the filter. Evaporation is carried out to dryness in the steam bath. Exercising the same precautions as those recommended above, the dish is cooled for 20 minutes in the vacuum dessicator and again weighed.

*Calculations.* Loss in weight $\times$ 20 = mg. per cent of phospholipids. Normal values by this method are 180 to 230 mg. per cent.

DISCUSSION

The earlier animal experiments in this field suggested that physiologic derangements consequent upon ligation of the thoracic duct(s) are incompatible with life. However, Munk and Friedenthal[8] and D'Errico[4] adduced the first evidence contrary to this view and in 1922 Lee[6] conclusively demonstrated its incorrectness.

Lee studied the postprandial distribution of chyle by feeding cats in whom the thoracic duct had been ligated a cream diet stained with Scharlach-R and Berlin Blue. The animals were sacrificed at periods varying between one and 77 days following operation, and anatomic studies were carried out. Two types

TABLE I

TOTAL BLOOD FATS    PHOSPHOLIPIDS

| DATE | | | (Mg. %) | (Mg. %) |
|---|---|---|---|---|
| Dec. | 4, 1946 | a.m. | — | |
| | | p.m. | 280 | |
| Dec. | 5, | a.m. | 164 | |
| | | p.m. | 346 | |
| Dec. | 6, | a.m. | 306 | |
| | | p.m. | 440 | |
| Dec. | 7,* | a.m. | 542 | |
| | | p.m. | 612 | |
| Dec. | 9, | a.m. | 364 | |
| | | p.m. | 552 | |
| Dec. | 10, | a.m. | 336 | |
| | | p.m. | — | |
| Dec. | 16, | a.m. | 312 | |
| | | p.m. | 340 | |
| Dec. | 17, | a.m. | 335 | |
| | | p.m. | 404 | |
| Dec. | 20, | a.m. | 455 | |
| | | p.m. | 500 | |
| Apr. | 7, 1947 | a.m. | 586 | 156 |
| Apr. | 8, | a.m. | 643 | 193 |
| Apr. | 9, | a.m. | 502 | 144 |
| Apr. | 10,‡ | a.m. | 736 | 190 |
| Apr. | 11, | a.m. | 560 | 154 |

* On High Fat Diet, 150 Gm.
‡ Fat Meal at Noon.

of newly established collateral channels were demonstrated: (a) those to the right thoracic duct and (b) those to the azygos vein and/or its branches. All this was, of course, consistent with the traditional concept of the transit of fats *from* the gut *to* the bloodstream by way of the thoracic duct.

That the movement of fats may and probably regularly does occur also in a direction opposite to that traditionally visualized, i.e., *from* the blood stream *to* the thoracic duct, was demonstrated in 1944 by Reinhardt, Fishler and Chaikoff.[12] These investigators injected radiophospholipids into the blood stream and were able to recover between 9 and 20 per cent of the lipids from the thoracic duct within three to six hours. It would be a matter of considerable interest to conduct a similar investigation under circumstances in which the thoracic duct is ligated before the injection of phospholipids.

The blood fat levels in our single human experience following ligation of the duct are at variance with the animal findings reported in 1904 by Munk and

Friedenthal.[8] These authors encountered an increase in blood fats, whereas we encountered a decrease. The reasons underlying this disparity of findings can only be speculated upon. A theoretically defensible mechanical account can be made out for either circumstance. It may prove possible to reconcile the disparities in terms of individual and/or species differences in respect of potential collaterals.

In the clinical and experimental studies thus far reported there appears to be a general agreement that following the development of chylothorax and chyloperitoneum the level of blood fats falls off. Shackelford and Fisher[13] summarized their own experiences and those of previous observers in this connection. They considered that the intravenous re-infusion of chyle recovered from the chest cavity has a somewhat salutary effect in raising the blood fat level and in combating asthenia and inanition.

The earliest recorded instance of inadvertent section of the thoracic duct incidental to splanchnicectomy and sympathectomy appears to be that reported upon by Crafoord in 1941.[2] In this case, the duct was severed at the level of the eleventh rib. The distal stump was crushed with a hemostat and buried in the adjacent mediastinal tissue. No untoward clinical manifestations developed. At the time of operation, Crafoord observed one undamaged branch of the duct and he was inclined to ascribe the fortunate outcome of his case to the presence of this vessel. He expressed the belief that when well developed lymphatico-venous anastomoses exist, ligation of the main trunk may be carried out without serious complication. He considered that when such anastomoses are deficient, clinical symptoms must supervene.

In 1942, Whitcomb and Scoville[15] reported a second case of accidental section of the duct in the course of splanchnicectomy and sympathectomy. In this instance, the duct was severed at the level of the first lumbar vertebrae and the distal stump was closed off by the application of a silver clip. For the first week, the patient's postoperative course was uneventful. Thereafter, signs of increasing respiratory embarrassment became evident. Chylothorax was then demonstrated and was dealt with by frequent thoracentesis. The patient's serum protein and fat levels fell off progressively and emaciation became severe in spite of the re-infusion of chyle recovered from the pleural cavity. The patient expired three weeks after operation under circumstances considered by the authors as indicative of anaphylactic shock. Permission for autopsy was not obtained but the authors postulated that the silver clip might have produced necrosis of the duct or that it might have become disengaged.

The available evidence leaves little room to doubt that the organism tolerates ligation of the thoracic duct far more readily than its section. The dynamic factors underlying this circumstance appear to hinge upon the matter of the restitution of homeostasis. Following ligation, a new gradient of hydro-dynamic pressure is at once established within a *closed* system. This gradient tends to promote the opening of potential collaterals and the development of supplementary channels. Following section of the duct, the preexisting pressure

gradients are actually increased, falling off rapidly from the "head of pressure" in the villi and mesenteric lymph channels to the cut end of the distal stump. The mechanical factors tending to promote the establishment of alternate pathways for the chyle are, under such circumstances, of negligible character. The result of this is a continuing and poorly compensated biochemical disequilibrium.

It seems unnecessary, therefore, to urge that when the duct is accidentally severed every effort should be made to isolate and carefully ligate the cut ends, particularly the distal stump. For such purpose, a silk suture ligature appears to afford greater security than that offered by mere crushing or clipping. In cases where it is not feasible to isolate the leaking stump, it may prove advantageous to suture a muscle stamp into place or to press a pledget of Gelfoam impregnated with thrombin and plasma against the opening.

The further management of the case should be guided by clinical developments and the results of repeated determinations of blood fat and serum-protein levels. If the latter should fall to levels that appear to threaten physiologic economy, the deficit can be dealt with by increasing the fats and proteins in the diet or by the parenteral administration of plasma, "Amigen" or other commercial preparations of the sort routinely employed in maintaining nutrition in the presence of severe burns and extensive decubitus ulcers.

### SUMMARY

1. The flow of chyle may be interrupted in the course of extra- or intrathoracic surgical procedures by inadvertent section or ligation of the thoracic duct. The great variations in anatomic pattern of the duct and in its relations to the splanchnic nerves requires that the surgeon be constantly on guard against such accidents.
2. Section of the thoracic duct is productive of chylothorax, a serious and often fatal complication characterized by respiratory embarrassment, asthenia and inanition. Ligation of the duct may be unaccompanied by subjective complaint and in any case is productive of a much less serious physiologic disorder than its section.
3. A case is reported in which, following inadvertent ligation of the thoracic duct, blood fat levels were determined throughout a period of sixteen days until physiologic levels were regained and maintained. The blood fat level was sharply reduced immediately after the accident to half its normal value. During the next two weeks, it gradually climbed to normal levels. A high fat diet (150 Gm.) temporarily restored the blood fats to low-normal levels. Clinically the patient exhibited no ill effects.
4. If the thoracic duct is accidentally severed at operation, every endeavor should be made to close the opening by suture ligature. Where this proves unfeasible, a muscle stamp or "Gelfoam" pledget should be employed. Postoperatively, the blood fat and serum protein levels should be determined at regular intervals. The frequency of such determination will depend upon the degree of biochemical disequilibrium demonstrated. If indicated, special

dietary and/or intravenous measures may be adopted in order to furnish needed fats and serum proteins.

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# STREPTOMYCIN IN SURGICAL INFECTIONS

## Part V. Infections of Soft Tissues

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THIS COMMUNICATION, the fifth of a series dealing with the streptomycin therapy of surgical infections in U. S. Army hospitals, is concerned with the results of this form of antibiotic therapy in infections of the soft tissues. The composite material on which it is based consists of case reports submitted to the Office of the Surgeon General and subjected by us to critical analysis, with the object of determining the present status of this antibiotic in the management of infected wounds. The ultimate goal of this investigative effort is to identify the indications for, the dosage of, and the adjuvant utility of, streptomycin in the treatment of impending and established wound infection.

### REVIEW OF LITERATURE

To date, only a small number of reports have been published concerning the use of streptomycin in soft tissue infections. Two of these were experimental studies. Kirby[1] and his associates produced virulent infections in dogs by traumatizing the spinal muscles and contaminating the wounds with cultures of staphylococci, streptococci, and colon bacilli. Both local and invasive infections were controlled when streptomycin was applied locally at the time contamination was introduced or when it was given parenterally every six hours for six days. All untreated animals, however, developed severe infections and 55 per cent of them died.

Howes[2] experimental study, which antedated that of Kirby and his associates, concerned streptomycin and sulfamylon (sulfabenzamine hydrochloride). He produced infections in the spinal muscles of rabbits by traumatizing them and introducing either cultures of bacteria or dirt scraped from the floor. Local injection immediately after injury of a solution containing 0.2 per cent streptomycin and 5 per cent sulfamylon prevented the development of infection. Infection was not prevented, however, if drug treatment was delayed three hours or more unless secondary wound excision was done concomitantly. Once infection had become established, treatment with the solution described failed to hasten resolution.

The few clinical studies reported in the literature are not conclusive. White[3] observed clinical improvement in respect to the type of granulation present and in respect to decrease, decolorization and thinning of drainage in 18 of 32 amputation stumps after local treatment for 24 to 72 hours prior to wound revision and skin grafting with packs soaked in 0.1 per cent solution of streptomycin. The remaining stumps were not improved, and neither in the improved

nor the unimproved cases were organisms eliminated consistently. Hirshfeld[4] reported that granulations became healthy and grafts took well in four sloughing or granulating wounds when streptomycin was applied topically in 0.05 per cent solution over an unspecified period of time. The bacterial flora was not altered, however, and the resistance to streptomycin increased remarkably. The results were disappointing when the drug was used parenterally in other types of soft tissue infections. Poor results were attributed to the presence of streptomycin-resistant organisms in mixed infections.

Keefer[5] and his associates, who supplied no details, stated that six patients with surgical wound infections had improved on parenteral or topical streptomycin therapy. Brooke[6] reported that in 10 cases of infected wounds, ulcers and burns, "good results in general" followed the topical application of 0.25 per cent parachlorophenol and 0.5 per cent streptomycin in a carbowax base for six to 30 days. Finally, M. E. Florey[7] reported that five out of six chronic sinus tracts residual to battle incurred injuries with predominantly gram-negative flora, became sterile when treated with streptomycin. All healed within three weeks of the end of treatment. The exceptions contained *Staphylococcus aureus* and *Streptococcus hemolyticus,* which were not eliminated until topical penicillin was applied.

### MATERIALS AND METHODS

The basis of this report is 102 streptomycin-treated infections of soft tissues in males of military age, including 67 cases of cellulitis, 33 of which were associated with abscess formation, 30 cases of localized infection, and five cases of specialized infection. The series represent all instances of infection observed over a given period of time. No fresh wounds are included. They represent a selection of cases, such as occurs in civilian practice, in which only patients refractory to standard methods of treatment reach the hospital for treatment and study.

Sixty-eight of the 102 patients were treated with streptomycin alone and 34 were treated with a combination of streptomycin and other bacteriostatic agents. The results of therapy were classified on the basis of the type of clinical response as good, doubtful, and poor.

*Bacteriology.*—Gram-positive cocci were the dominant organisms in 61 of the 102 cases which make up this series. Staphylococcus aureus and hemolytic streptococci were found in pure culture, alone or in combination in 20 cases, and gram-negative bacilli were cultured alone in 16 cases. Mixed infections were present in 20 cases. In the remaining five cases, there was no drainage.

The cultures of bacteria were tested for streptomycin sensitivity in all but five cases. Eighty-five per cent of the gram-negative bacteria were found to be sensitive, that is, they were inhibited in vitro by concentrations of streptomycin easily maintained in the blood stream (16 micrograms per milliliter or less). Eighty per cent of all staphylococci and streptococci were streptomycin sensitive, and the remaining 20 per cent were only moderately resistant. All anaerobic gram-positive bacilli tested were insensitive.

## ANALYSIS OF RESULTS

### Streptomycin Treated Cases

Streptomycin was the only antibacterial agent employed in the treatment of 68 cases (Table I). The results were classified as good in 47, doubtful in seven, and poor in 14. Details of the first 27 cases follows:

*Improved Group.*—Eight of the 12 patients regarded as benefited by streptomycin therapy had cellulitis, in five instances associated with abscess formation, and four had localized infections.

Two of the three patients with cellulitis without abscess formation were treated by the intramuscular route. The first patient, who had myelogenous leukemia, had a cellulitis in the cervical region from which streptomycin-sensitive Salmonella typhimurium was cultured. The second, three days after excision of a pilonidal sinus with primary closure of the wound, developed an infection from which streptomycin-sensitive *Escherichia coli* and hemolytic streptococci were cultured. In both instances prompt resolution of the inflammatory process and satisfactory healing followed treatment with streptomycin.

TABLE I.—*Results of Therapy in 68 Infections of Soft Tissues Treated by Streptomycin Only* ***

| DIAGNOSIS | No. of Cases | Range of Dosage* | ——RESULTS—— | | |
|---|---|---|---|---|---|
| | | | Good | Doubtful | Poor |
| Cellulitis | 18 | 1.8--3.0 | 15 | 1 | 2 |
| Cellulitis with abscess | 26 | 1.0—2.4 | 25 | 1 | |
| Wound suppuration* | 10 | | 7 | 2 | 1 |
| Sinus tracts | 8 | 1.0—1.5 | | | 8 |
| Septic burns | 3 | 2.4 | | 2 | 1 |
| Chancroid | 1 | 2.4 | | | 1 |
| Meloidosis | 1 | 2.4 | | | 1 |
| Decubitus ulcer | 1 | 2.4 | | 1 | |
| Total | 68 | 1.0—3.0 | 47 | 7 | 14 |

* In Gm. per day.

** Applied topically, in concentrations of 1-10 mg. per milliliter.

*** This table was remade after the article was prepared for publication, so as to the author's 41 cases, 13 of cellulitis, 21 of cellulitis with abscess, 6 of wound suffuration, and 1 septic burn. The entire series suggests that streptomycin parenterally administered in doses of 2.0 to 3.0 Gm. a day is equally effective as penicillin against gram positive coccal cellulitis and cellulitis with abscess caused by streptomycin susceptible organisms.

The third patient with non-localizing cellulitis developed the infection 15 days after a plastic operation on the hand which included tendon transplants, and tendon, fascial and bone (iliac) chip grafts. Culture revealed Proteus vulgaris and *Staphylococcus aureus,* both sensitive to streptomycin. The wound was re-opened under parenteral streptomycin protection and infected, necrotic tendon and fascial grafts were removed; the bone chips and tendon transplants were maintained. Localization of the infection was observed within 48 hours and supplemental topical application of streptomycin by means of wet dressings was followed by the formation of clean, bright red granulations and good wound healing.

In all five cases of cellulitis with abscess formation localization followed a more rapid pattern than is ordinarily observed following drainage only. Results

were prompt and permanent in four cases: (1) a presacral decubitus ulcer in a paraplegic treated by the parenteral route; (2) a mixed wound infection, due to gram-negative and gram-positive streptomycin-sensitive organisms, treated by the local and parenteral routes; (3) an inguinal infection following an old gunshot wound treated by drainage and parenteral streptomycin; and (4) an infection following repeated aspirations of a seroma complicating cranioplasty. In the latter case which was treated with intramuscular and topical streptomycin, removal of the tantalum plate was necessary.

In the fifth case of cellulitis with abscess formation the course was less smooth probably because the initial streptomycin therapy was inadequate. A recurrent draining infection in the left groin, associated with embedded shell fragments of small size and caused by streptomycin-sensitive gram-positive cocci and Proteus vulgaris, was first treated by daily instillations of a 0.5 per cent streptomycin solution followed by streptomycin in an ointment base. Healing was prompt, but two days after it was apparently complete there was a severe recurrence, manifested by local pain, chills and fever. Streptomycin was given parenterally for four days, after which local therapy was substituted. Localization and spontaneous drainage had occurred through the original wound during parenteral treatment and healing again seemed satisfactory. Two weeks later a second recurrence was treated for eight days with 0.4 Gm. of streptomycin every four hours intramuscularly. Resolution of this abscess occurred within 48 hours with spontaneous drainage. This third course of treatment, which was the first adequate course, apparently resulted in sterilization of the wound and there has been no recurrence in the ensuing eight months.

The four cases of localized infection treated successfully by streptomycin illustrate the ability of this drug to eliminate susceptible bacteria persisting in wounds in which no slough is present. One infection, following radial neurorrhaphy, had not responded to drainage, wet dressings, and treatment by other bacteriostatic agents over a period of six weeks. When topical streptomycin therapy was introduced, cultures which had previously yielded streptomycin-sensitive Pseudomonas aeruginosa became sterile within six days and drainage ceased on the tenth day of treatment. Healing thereafter was satisfactory.

The other three cases in this group were all low-grade infections in anophthalmic sockets caused by streptomycin-sensitive coagulase-positive hemolytic Staphylococcus aureus. These infections, which ordinarily respond well to penicillin, seemed to respond equally well to instillations of aqueous sterile streptomycin solution (5 mg. per milliliter) two or three times daily for three to five days. The chief advantage of streptomycin over penicillin in such cases lies in the fact that it is thermostable, so that solutions can be warmed to body temperature and the patient's comfort thus be increased. This advantage, however, would be outweighed by the possibility of the development of drug-fastness if the organisms were not eliminated promptly.

*Doubtful Cases.*—Streptomycin was of possible value in two cases in

which it was used prophylactically and postoperatively. The first was a decubitus ulcer of the heel, from which *Escherichia coli* was cultured. Primary healing followed surgical excision and pedicle flap closure. In the second case appendectomy for acute disease was necessary in a patient with *Pseudomonas aeruginosa* infected second and third degree burns of the entire abdomen. The postoperative course was without incident and it was thought that the exudate from the burned area was considerably reduced while streptomycin was being given.

*Poor Results.*—Nine of the 13 patients who did not respond satisfactorily to streptomycin therapy had draining sinus tracts of diverse origins. One followed nephrectomy and three followed wounds of the bladder. In one of the latter cases the organisms had become resistant to streptomycin and did not respond to a second course of therapy, although a previous course had resulted in closure of a suprapubic wound. In a similar case the organisms were resistant initially to streptomycin. In still another case, five courses of streptomycin therapy, all adequate, produced no results. The unsatisfactory outcome in all these cases suggests that streptomycin therapy alone is unlikely to be followed by closure of a fistulous tract connected with the bladder if the sinus has become chronic and scar tissue is present. The causative organisms may be sensitive to the drug in vitro, but surgery must be combined with streptomycin if the desired results are to be attained.

Other cases in this group included a sinus following perforation of the splenic flexure with an intraperitoneal abscess, in which the organisms were found to be streptomycin-resistant before therapy was undertaken; a sinus of the buttock following retroperitoneal trauma; a complicated fistula-in-ano for which fistulectomy was performed; a sinus following coccygectomy; and multiple sinuses of the scrotum and peri-anal region in a patient with chancroid. The last two cases deserve special comment. In the infection which followed coccygectomy the exudate became scanty and gram-negative organisms were eliminated, but gram-positive varieties persisted and became drug-fast. Chemotherapy was ill chosen in this case. Obliteration of the tract could not have been anticipated without surgical collapse of the bony wall. The patient with chancroid had a progressive, two-year history of multiple draining sinuses in the scrotum, perineum and inguinal and pubic areas, from which *Hemophiliusis ducreyi* sensitive to streptomycin was repeatedly isolated. Several courses of parenteral streptomycin therapy, two of which were supplemented by penicillin and sulfathiazole, produced only transient improvement. Recurrence was prompt after the cessation of treatment. The organisms eventually became drug-fast.

There were four chronic localizing infections. Infection remained in two open amputation stumps because removal of necrotic tissue was not complete. Decrease in the discharge during therapy was deceptive in that it was not permanent. The third patient had a chronic cervical abscess caused by *Malleomyces mallei*. In vitro streptomycin resistance of the organisms was

established, but treatment over 57 days, as a last resort, was ineffective. The fourth patient had extensive badly infected third degree burns of both legs and one arm. There was a progressive decrease in the amount of exudate during treatment, but some of the organisms became refractory to the drug. While skin grafting was finally successful, surgical elimination of sloughing tissue, and not streptomycin therapy, was regarded as the dominant factor in reducing the severity of the infection.

### COMBINATION-TREATED CASES

Results in the 34 cases treated by streptomycin in combination with penicillin or sulfadiazine or both (Table II) were good in 14, doubtful in four, and poor in 16.

*Good Results.*—In this group of cases in which treatment was successful there were 13 instances of cellulitis, one with abscess. There were four caused by *Staphylococcus aureus,* four were caused by gram-negative bacteria, and

TABLE II.—*Results of Therapy in 34 Infections of Soft Tissues*
*Treated by Streptomycin and Other Bacteriostatics*

| DIAGNOSIS | No. of Cases | Range of Dosage* | RESULTS Good | Doubtful | Poor |
|---|---|---|---|---|---|
| Cellulitis | 16 | 1.5—3.0 | 12 | | 4 |
| Cellulitis with abscess | 4 | 1.8—3.0 | 1 | | 3 |
| Wound suppuration** | 2 | | 1 | 1 | |
| Sinus tracts | 7 | 2.4 | | 3 | 4 |
| Ischiorectal abscess | 3 | 3.0 | | | 3 |
| Bacterial synergistic gangrene | 1 | 2.4 | | | 1 |
| Actinomycosis | 1 | 1.8—2.4 | | | 1 |
| Total | 34 | 1.5—3.0 | 14 | 4 | 16 |

* Streptomycin in Gm. per day. Sulfadiazine was given in doses of 6 Gm. per day and the minimum dose of penicillin was 240,000 units per day.
* Applied topically, in an ointment base containing 5 mg. of streptomycin per Gm.

three were found to have mixed gram-positive and gram-negative organisms. No cultures were obtained in two cases. Penicillin in adequate doses (ranging between 240,000 and 1,000,000 units per day) had not been successful in controlling the infection in any of these cases, but the prompt, and sometimes dramatic, results achieved following the addition of streptomycin to the therapeutic regimen seemed to point to it as the responsible agent. Streptomycin therapy was considered responsible for the favorable outcome in the case of cellulitis with abscess caused by staphylococci resistant to penicillin but sensitive to streptomycin. The infection, following a cartilage transplant to the nose, showed no improvement after 18 days of penicillin therapy.

A case of localized staphylococcic infection was found in a traumatic ulceration of the lower abdominal wall. In spite of topical and parenteral penicillin therapy the infection had reached the anterior rectus sheath by the forty-first day, and presented a crater on the surface measuring 5 by 10 cm. The local application of 0.5 per cent streptomycin in a water-in-oil emulsion base resulted in complete healing by the 31st day of treatment; all organisms had disappeared from the wound by the twenty-seventh day.

*Doubtful Results.*—In four cases the prophylactic administration of strep-

tomycin may have been helpful in securing uncomplicated primary wound healing. A decubitus ulcer of the leg, in which *Escherichia coli* was the predominating organism, was treated by excision and pedicle flap closure. A sinus tract in the leg, not originating in bone, from which penicillin-resistant, streptomycin-sensitive *Staphylococcus aureus* was isolated, could be treated by split thickness skin graft four days after irrigations with 1 per cent streptomycin solution were begun. A sinus tract following cholecystectomy, which had drained for eight months, was successfully closed, the only complication being a seroma in the wound which yielded no growth on culture. Culture in this case yielded *Staphylococcus aureus* and *Bacillus proteus* resistant to penicillin but sensitive to streptomycin.

The fourth case in this group was a sinus following nephrectomy performed two years earlier but shown by pyelography and lipiodol injections not to be connected with the urinary tract. Penicillin-resistant *Staphylococcus aureus* was cultured from the purulent exudate released at operation. Penicillin and streptomycin in sterile dried plasma powder (1:5) was applied locally at each dressing and successful plastic closure of the wound was accomplished within a short time.

*Poor Results.*—The 16 cases in which combined bacteriostatic treatment was not successful included a variety of conditions. Three ischiorectal abscesses and four cecal fistulas did not respond to various combinations of local and parenteral streptomycin. In one case of furunculosis the original infection was apparently controlled at the end of seven days, but other furuncles appeared 14 days later while the patient was still under treatment. In a second case of furunculosis, severe dizziness and nausea made it necessary to discontinue the drug at the end of 24 hours. Two patients, submitted to tenorraphy for battle-incurred injuries of the hand, developed severe postoperative infections which did not improve until wound revision was performed. In another case, massive cellulitis of the groin, with extravasation of urine as a late complication of traumatic rupture of the urethra, was treated by incision and drainage after 1 Gm. of streptomycin had been given daily for two days. Transient improvement was followed by the formation of additional abscesses; treatment in this case was carried out for only five days and was plainly inadequate. In one case of cellulitis following removal of the lower half of the fibula for osteomyelitis, and in another of infection following cartilage graft of the nose, no treatment was satisfactory until the wounds were revised. In the former case, considerable necrotic tissue was present and in the latter, the implant had to be removed. In one case of abdominal actinomycosis which had developed a year and a half after drainage of an abdominal abscess, there had been no response to numerous other forms of therapy, including penicillin, and improvement was only transient after each of three adequate courses of parenteral streptomycin therapy.

The last case in this group of failures was of particular interest. Typical postoperative synergistic bacterial gangrene developed after incision and

drainage of a peritoneal abscess, and by the fifth day the gangrenous area was approximately 15 cm. in diameter. The infection advanced rapidly, in spite of debridement (which was only partial because of the risk of evisceration), penicillin and sulfonamide therapy, until it involved the rectus muscle and extended into the fascial planes. Streptomycin was given intramuscularly, in combination with other therapy, in doses of 4 Gm. daily for five days. It was no more effective than other treatment had been and the patient eventually succumbed to the progressive infection.

### REACTIONS

Exclusive of pain at the site of injection, of which numerous patients complained, undesirable reactions were recorded in eight of the 61 cases treated by streptomycin. No reaction occurred in patients receiving less than 2 Gm. of the drug daily. In four instances, the undesirable effects were noted after only brief periods of therapy. In two patients, severe dizziness and nausea developed on the first and second day of treatment, respectively. In one of these cases, the drug was withdrawn but in the other, treatment was continued without difficulty with streptomycin from another batch. In two other cases, a generalized rash appeared on the eighth and twelfth days of treatment, respectively. In both instances the drug was withdrawn. The rashes disappeared promptly. In the four remaining cases, vertigo followed the administration, respectively, of 50 Gm. of streptomycin over a period of 16 days, 54 Gm. over 30 days, 104 Gm. over 35 days, and 114 Gm. over 57 days. In every instance withdrawal of the drug was followed by prompt subsidence of the disturbance.

An analysis of these cases shows, as has previously been demonstrated, that streptomycin is a relatively safe drug when it is administered in doses up to 3 Gm. daily for as long as 14 days. Longer courses of therapy may be associated with labyrinthine disturbances, the severity of which is usually in proportion to the duration of therapy.

As these reactions indicate, streptomycin is an agent which has toxic potentialities. No serious permanent sequelae were noted in any case in this series, but it is obvious that the effective dosage of 3 Gm. daily is close to the critically toxic level. Any means of reducing the effective daily dosage would therefore be desirable.

### COMMENT

Although 61 streptomycin-treated infections of the soft tissues do not constitute a large series; the cases are sufficiently representative to indicate both the possibilities and the limitations of streptomycin as an adjuvant in the therapy of wound infections in soft tissues. At the present time, therefore, it seems possible to make certain definite statements concerning this bacteriostatic agent.

Good results cannot be expected from streptomycin therapy unless certain conditions are met:

(1) The organism (organisms) responsible for the infection must be streptomycin-sensitive.

(2) The drug must be given in adequate dosages.

(3) There must be little or no necrotic tissue present.

(4) The blood supply to the affected site must be adequate.

The cases in this series in which poor results followed streptomycin therapy were almost without exception cases in which the principles laid down for its use were violated. Many of them illustrated the unfortunate but rather general tendency to institute chemotherapy or antibiotic therapy without regard to the fundamental principles of surgical management. In four cases the organisms were known to be streptomycin-resistant. In two cases the dosage was inadequate. In eight cases dead tissue or foreign bodies were present. In 15 cases sinus tracts or scar tissue of other origins represented precisely the kind of tissue devitalized by trauma or sepsis or rendered avascular by sclerosis which cannot be sterilized by any known form of chemotherapy or antibiotic therapy.

Streptomycin apparently has its chief field of usefulness in acute infections complicated by cellulitis. When it was used for this type of infection in this series, complete resolution usually occurred without necrosis of the affected tissue and with satisfactory wound healing.

Streptomycin also has a field of usefulness in the therapy of acute gram-positive coccal cellulitides which are penicillin-resistant. Streptomycin also may be employed in the occasional case of gram-positive coccal infection in which the patient has developed a penicillin-sensitivity reaction. In the small number of cases in this series which fell into these categories the results were generally good. Streptomycin is probably even more useful in mixed infections in which the response to penicillin alone is not satisfactory because some organisms present are not penicillin sensitive and may, in fact, exert an actual penicillin-destructive effect.[8]

It is considerably more difficult to define the usefulness of streptomycin applied topically in localized infections with cellulitis. Some cases in this series improved under this form of treatment but the results were not dramatic in any instance. The impression was frequently received that the patients would probably have fared as well if streptomycin had not been used. Moreover, even in the improved cases, it was not possible to attribute the good results to streptomycin alone. They might equally well have been attributed to the mechanical clearing effect of improved drainage, or to combined surgical-antibiotic therapy. The results, in fact, seem to suggest that if local wound suppuration is not completely controlled within a period of 72 hours after the topical application of streptomycin is begun, the interpretation is warranted that whatever other function the local dressings may be fulfilling, their effect is probably not bacteriostatic.

Even when all the conditions set down for the proper use of streptomycin are met, it still does not follow that streptomycin therapy is the method of

choice in a given case. This is an extremely expensive drug. It is, moreover, an agent which is not free from risk, the optimum therapeutic dose, as has been pointed out, apparently being dangerously near to the critically toxic level. It therefore should be used in the type of case in which its usefulness has been established, only if no other drug will answer the purpose equally well. In the greater majority of cases penicillin will be equally effective. A distinction should be made, in other words, between cases in which streptomycin is indicated and cases in which it is mandatory. Available statistics seem to indicate that the cases in the mandatory category are not more than one in every 85.

Precise clinical standards do not exist for the ready selection of cases in which streptomycin is mandatory. For the present, the most that can be said is that it probably should be used:

(1) In mixed gram-positive and gram-negative infections in which clinical experience has shown that the results of penicillin therapy tend to be inconstant.

(2) In gram-positive infections in which there has been no response to maximal doses of penicillin within 48 to 72 hours, or earlier, if in vitro evidence of penicillin resistance can be secured.

(3) Generally speaking, in infections below the diaphragm, where gram-negative infections and mixed infections occur predominantly. Reclassification of this series of cases according to bacteriology made clear that infections of this origin were infrequent above that level. This is a practical point which may be of assistance if laboratory facilities are not readily available.

(4) In an occasional case, in the form of topical applications, to remove bacteria, in conjunction with a surgical procedure designed to eliminate dead or sloughing tissue. It should be remembered that the mere presence of gram-negative organisms in an infection of long duration is not per se an indication for streptomycin therapy. They are probably present as part of the evolution of the bacteriology of the wound, and until dead tissue is removed, streptomycin cannot be expected to be effective against them.

When streptomycin is used, it must be given in adequate dosage. The optimal dose, when it is used alone, is 2 to 3 Gm. daily, the duration of treatment depending upon the response. If treatment is discontinued too soon after a favorable response is apparent, recurrence is likely. On the other hand, if therapy must be continued longer than 14 days, the dosage should be reduced, to avoid the risk of labyrinthine disturbances.

The optimum dosage of streptomycin in combination with penicillin has not yet been worked out. From present indications it will be considerably less than the 2 to 3 Gm. daily now regarded as optimum when streptomycin is used alone. Probably it will not be more than 1 to 1.5 Gm. daily, given intramuscularly in 0.25 Gm. doses every four hours, in combination with 50,000 units of penicillin every four hours by the same route. Investigations to establish this point are currently being conducted.

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# PENICILLIN IN THE POSTOPERATIVE TREATMENT OF PEPTIC ULCER WITH PERFORATION AND APPENDICITIS WITH PERFORATION[*]

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THIS REPORT is based on a study of the 42 cases of perforated peptic ulcers and 97 cases of perforated appendices operated at the Philadelphia Naval Hospital during the eighteen month period between January 1, 1946, and June 30, 1947. Patients from the Veterans Administration and active duty personnel are included in the series. Since the vast majority of these cases were surgical emergencies, operation was performed by the surgical watch officer. This officer is usually a younger surgeon with experience comparable to that of a surgical resident or younger staff man in a civilian hospital. There has been no rigid standardization of surgical procedure, the details of which have varied somewhat with the individual operator.

On the other hand the postoperative care in this series has been quite uniform throughout for each of the two groups of patients. In practically all of these cases the same ward medical officer supervised this care. With few exceptions, which will be noted, penicillin was administered postoperatively. Although some of the cases treated early in 1946 and an occasional case treated later received a smaller dosage of penicillin, 100,000 units every two hours became the accepted initial postoperative dose.

Penicillin in this dosage for appendicitis was suggested by Crile and Fulton.[1] Whether one subscribes whole-heartedly to the theoretical considerations upon which they based their use of relatively large doses of penicillin, one is forced to admit that their results in 1500 appendectomies, both from the standpoint of morbidity and mortality, are enviable.

In the past few years many reports on the treatment of perforated peptic ulcer and acute appendicitis with or without perforation have been published. Improved results have been attributed to chemotherapy and antibiotics alone or in combination with various operative and postoperative factors. Baritell[2] reports 88 perforated gastroduodenal ulcers operated in three years with one death (1.1%). He describes his operative and postoperative routine in detail which includes sulfadiazine intravenously and orally. No penicillin was used. The commonest complication in this series was wound infection (10.2%).

Thompson and Prout[3] in an article on the surgical treatment of peptic ulcer include 100 cases of acute perforation. Chemotherapy was used in 91% and penicillin in 14%. The mortality rate was 15%, and 34% of the patients

developed wound infections. Estes and Bennett[4] operated upon 80 cases of perforated gastroduodenal ulceration. Their mortality rate was 8.7%. They attributed this relatively low rate to early surgical intervention, use of spinal anesthesia, immediate postoperative use of plasma, glucose, saline and sulfonamides.

Graham and Tovee[5] report their experience with 114 cases of perforated duodenal ulcer, 111 of which were treated surgically. The postoperative mortality rate was 6.3%. They emphasize the importance of preoperative treatment, even to delaying operation up to twelve hours. They decry the use of intraperitoneal sulfonamides.

Stafford, Beswick, and Deeb[6] reviewed 903 cases of acute perforative appendicitis. They found that with increasing use of sulfonamides the mortality rate decreased from 9.2% in 1939 to 3.4% in 1942. They conclude that the sulfonamides are effective in the treatment of peritonitis and of particular value when implanted intraperitoneally in the early stages. Newell[7] operated upon 48 cases of suppurative appendicitis with free pus in the peritoneal cavity. There were no deaths. In all cases 5 Gm. of sulfanilamide powder were placed in the peritoneal cavity which was not drained. Penicillin was used in large dosage in 11 cases.

Farkas[8] analyzed 648 cases of acute appendicitis treated surgically. Sulfonamides were given orally or intravenously to patients with evidence of peritonitis. Mortality rate was 1.65%, all deaths occurring in the group with perforated appendices and generalized peritonitis.

Ochsner and Johnston[9] compared results of treatment of patients with perforated appendices admitted to Charity Hospital in 1933 with those admitted in 1943. In 1933 the mortality rate was 15%. In 1943 it was 5.2%. The improvement is attributed not only to use of sulfonamides, but also to the administration of large amounts of blood and plasma, the employment of gastro-intestinal decompression, and the use of oxygen.

Mueller[10] in 1945 reported his experience with 739 cases of appendicitis in which local sulfonamides had been used in 320 instances. Penicillin was used postoperatively in the cases with abscess or peritonitis. Mortality rate was 0.4%. In a group of 742 treated prior to the use of chemotherapy and antibiotics, the mortality rate was 2.83%.

Experimental evidence points to the value of penicillin in the treatment of intraperitoneal infection. Fauley, Duggan, Stormont, and Pfeiffer[11] produced peritonitis in dogs by ligating the appendiceal base and blood supply. The mortality in 27 untreated controls was 92.7%. Of 48 dogs which were treated with penicillin and which did not develop fecal fistulae none died. If fecal fistulae did develop the animal died in spite of penicillin therapy. Harper and Blain[12] isolated jejunal loops in dogs. Fifteen control dogs died within 6½ days. Fifteen dogs receiving penicillin in the closed loop and five receiving penicillin parenterally were protected for significantly longer intervals. Their evidence showed that penicillin given prophylactically in large doses can

prevent infection of the distended intestinal wall by normal intestinal bacteria.

We are presenting our experience with large dosage of penicillin in the postoperative treatment of perforative appendicitis and perforated peptic ulcer not with the idea of attributing the results obtained to the antibiotic agent alone. We have neither sufficient clinical nor bacteriologic control data to justify such a conclusion. Use of penicillin was an integral part of a routine postoperative regime (Tables I and II), which we feel has contributed to the relatively low mortality and morbidity in each of the two groups of cases. It is hoped that this report may add to the accumulating data in the literature on the value of penicillin in intraperitoneal infections; data which will ultimately yield groups of sufficient size for critical breakdown and analyses of statistical significance.

TABLE I.—*Postoperative Routine—Perforated Ulcers*

1. 100,000 u. penicillin q. 2 hr. = initial dosage level.
2. Wangensteen suction drainage—usually continued 48-72 hrs.
3. Intravenous fluids as indicated: (blood, plasma, serum albumen, amigen, glucose, saline).
4. Ascorbic acid and thiamin chloride parenterally until oral feeding started
5. Modified Sippy Diet—after Wangensteen drainage discontinued.
6. Early ambulation in the absence of signs and symptoms of peritonitis.

### PERFORATED PEPTIC ULCER

In this group there are 42 patients. Since the majority of these patients are veterans the associated factors commonly accepted as important in evaluating therapeutic results approach those of a civilian group except for sex distribution.

The ages of the patients ranged from 19 to 59. Nearly half of the perforations occurred in the third decade. Age distribution for the whole group is shown in Table III. The two patients who died were 27 and 29 years old.

TABLE II.—*Postoperative Routine—Perforated Appendices*

1. 100,000 u. penicillin q. 2 hr. = initial dosage level.
2. Wangensteen suction drainage in all cases of spreading peritonitis and in others with distension, vomiting, etc.
3. Intravenous fluids as indicated: (blood, plasma, serum albumen, amigen, glucose, saline).
4. Ascorbic acid and thiamin chloride—parenterally or orally.
5. Diet as tolerated.
6. Early ambulation in the absence of signs and symptoms of peritonitis.

In all but one case the time of perforation was established by the typical acute onset of severe, "doubling up," epigastric pain. Twenty-four (57%) of the patients gave a history or had had studies and treatment which justified the diagnosis of peptic ulcer prior to perforation. Several of the remainder of the group had a few days to weeks premonitory symptoms, but no definite previous attack or diagnosis. The time interval between perforation and operation is recorded in Table IV. Only 6 (14%) of the group were operated under six hours. Twenty-four (57½) received their surgery in less than 12

hours. Two were over 24 hours and two more over 48 hours in duration. The two deaths occurred in patients whose ulcers had perforated 15 hours and 62 hours before operation.

The admission temperatures, pulse rates, and leucocyte counts were studied with the following findings: Temperatures ranged from 97 to 102, but in the vast majority of instances the preoperative temperature was below 100. On the other hand the pulse rate was more strikingly elevated, being over 100 in approximately half of the cases. In all cases the leucocyte count was over 10,000, and in half of the cases over 20,000 with a polymorphonuclear increase and shift to the left.

TABLE III.—*Age Distribution—Perforated Ulcers*

| Years | No. of Cases | Per Cent of Group |
|---|---|---|
| Under 20 | 1 | 2.4 |
| 20 - 30 | 19 | 45.2 |
| 30 - 40 | 7 | 16.7 |
| 40 - 50 | 7 | 16.7 |
| Over 50 | 8 | 19.0 |

Roentgenologic examination for free air in the peritoneal cavity was made in 27 instances (64%). Air was demonstrated in 17 (63%) of those so examined.

An attempt has been made in Table V to classify the perforations as to location, but anyone familiar with this type of surgery realizes the difficulty of sharply localizing the lesion when landmarks are obscured by oedema.

TABLE IV.—*Duration of Perforation—Ulcers*

| Hours | No. of Cases | Per Cent of Group |
|---|---|---|
| 0 - 6 | 6 | 14.3 |
| 6 - 12 | 18 | 42.9 |
| 12 - 18 | 9 | 21.4 |
| 18 - 24 | 1 | 2.4 |
| 24 - 48 | 2 | 4.8 |
| 48 - 72 | 2 | 4.8 |
| Not Recorded | 4 | 9.4 |

induration, and exudation. About one-third of the perforations were listed in the operative report as gastric, about one-third as duodenal, and a final third were simply reported as pyloric. In two cases the lesions were marginal or rather jejunal in location.

Details of operative technic will not be discussed except for a few brief notes. Spinal anesthesia was employed in all but one instance. The exception received ether and was one of the patients who died. An upper right rectus incision was used most frequently with an occasional transverse incision as the operator's choice. One jejunal perforation was operated upon through a left subcostal incision. All of the perforations were treated by simple closure with or without a reinforcing tab of omentum. Sulfonamides were used locally in 13 cases; 5 grams of sulfanilamide being the usual dose. All abdominal wounds were closed in layers but suture material varied to include catgut, cotton, and wire.

Thirty-one cases (74%) were drained. In analyzing the drainage cases

for an indication the following facts are revealed: In six of the 11 cases the interval between perforation and operation was over 12 hours. In these six cases are included the two who died, one of whom had a full blown peritonitis at operation 62 hours after perforation, and the other a tremendous amount of gastric content in the peritoneal cavity. Culture of the fluid from this latter case revealed hemolytic streptococcus and pneumococcus. In two other cases the operator notes that there was a considerable amount of free peritoneal spillage. In the remaining three cases there was no obvious reason for draining other than the surgeon's choice.

TABLE V.—*Location of Perforated Ulcers*

| Classification | No. of Cases | Per Cent of Group |
|---|---|---|
| Gastric | 12 | 28.6 |
| Duodenal | 12 | 28.6 |
| Pyloric | 15 | 35.6 |
| Jejunal | 2 | 4.8 |
| Not Recorded | 1 | 2.4 |

All patients in this group received penicillin postoperatively. In 34 cases the initial dosage was 100,000 units every two hours. Dosage was continued at this level for varying lengths of time up to 18 days in one patient. The average duration at this level was 8.5 days. Penicillin was then tapered off through decreasing dosage before being discontinued. Four cases received an initial dosage of 50,000 units every three hours and the remaining four a still smaller dosage. Both deaths occurred in the smaller dosage group

TABLE VI.—*Postoperative Complications—Perforated Ulcers*

| Type | No. of Cases | Per Cent of Group |
|---|---|---|
| Pulmonary | 5 | 11.9 |
| Wound | 2 | 4.8 |
| Peritonitis (fatal) | 1 | 2.4 |
| Pelvic Abscess | 2 | 4.8 |
| Duodenal Fistula | 1 | 2.4 |
| Uremia (fatal) | 1 | 2.4 |

before the 100,000 units every two hours was established as a routine. In two cases, including the death from peritonitis, sodium sulfadiazine was given intravenously in the first 24 hours in 5 Gm. dosage.

Postoperative complications are listed in Table VI. An uneventful convalescence was enjoyed by 32 patients (76%). There were three cases of transient atelectasis, one of the right lower and two of the left lower lobe. All cleared uneventfully. There was one case of bronchopneumonia in a patient with a ruptured jejunal ulcer who had in addition a disruption of his left subcostal wound. This was not accompanied by evisceration. The wound was packed, strapped and allowed to heal by granulation. The only other wound complication was a hematoma in the upper end of a right rectus incision. There were two complicating pelvic abscesses which subsided following spontaneous rupture into the rectum. One of these patients with a pelvic abscess also had a pneumonitis. The most serious and troublesome complication of all was a duodenal fistula. This fistula closed spontaneously but only after three weeks of supportive treatment which included jejunal feeding through a Miller-Abbott tube.

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Two of the patients in the series died; a mortality rate of 4.8%. In the first instance the perforation was 62 hours old and the patient was critically ill on admission. After much controversy operative treatment was elected. Widespread peritonitis was found. The patient died of overwhelming infection 40 hours after operation. The second case was that of a 15-hour-old perforation in a mild diabetic who died in uremia 22 days after operation.

TABLE VII.—*Age Distribution—Perforated Appendices*

| Years | No. of Cases | Per Cent of Group |
|---|---|---|
| Under 20 | 9 | 9 |
| 20 - 30 | 54 | 55 |
| 30 - 40 | 19 | 20 |
| 40 - 50 | 3 | 3 |
| Over 50 | 12 | 13 |

ACUTE APPENDICITIS WITH PERFORATION

During the eighteen month period covered by this study 815 appendectomies were performed. In 166 cases (20%) the appendix was not acutely inflamed. In 552 instances (68%) the appendix was acutely inflamed or gangrenous but not perforated. In the remaining 97 cases (12%) a diagnosis of acute appenditis with perforation was made. It is with this latter group of perforated appendices that this report is primarily concerned.

TABLE VIII.—*Duration of Symptoms—Perforated Appendices*

| Days | No. of Cases | Per Cent of Group |
|---|---|---|
| 1 or less | 31 | 32 |
| 1 - 2 | 19 | 20 |
| 2 - 3 | 14 | 14 |
| 3 - 4 | 3 | 3 |
| 4 - 5 | 6 | 6 |
| 5 - 6 | 2 | 2 |
| 6 - 7 | 7 | 7 |
| Over 7 | 15 | 16 |

As with the ulcer group, certain factors considered important in prognosis and treatment will be discussed. Ages ranged from 16 to 73 with approximately half of the patients in the third decade of life (Table VII). A study of the time elapsing from the onset of symptoms to operation is summarized in Table VIII. It was interesting to find that perforation had occurred in as short a time as four to five hours and in 31 of the cases (32%) in less than one day. On looking for factors which might have contributed to appendiceal perforation it was found that at least 29 patients (30%) had taken cathartics, enemas, or both, prior to admission to the hospital. In four instances the laxatives were prescribed by physicians. In seven cases patients had been seen by an outside physician without the correct diagnosis being suspected and with resultant delay in treatment.

A study of the preoperative temperatures, pulse rates, and leucocyte counts showed that in 63 cases (65%) the initial temperature was over 100, but in only 36 patients (37%) was the pulse rate that high. This picture is quite different from that of the ulcer group. The difference is a predictable one, however, when one considers that the relatively low temperature and rapid

pulse rate of the ulcers is a reflection of the more severe peritoneal irritation commonly associated with that type of perforation. The leucocyte counts in the appendicitis group ranged from 6,400 to 29,400 with 62 (64%) of the counts between 10,000 and 20,000.

Spinal anesthesia was used in all 97 cases. The abdomen was entered through a right lower quadrant muscle splitting incision in 70 patients, a right rectus incision in 23, and in three instances the type is not recorded in the operative report. An inguinal incision was used in one case in which the appendix had perforated into a right indirect inguinal hernial sac and in which the preoperative diagnosis was strangulated hernia.

In Table IX the cases are listed according to the type or extent of intraperitoneal infection associated with the appendiceal perforation. In 18 (19%) of the cases a generalized or perhaps better termed, a spreading peritonitis was found. In 23 (24%) the process was apparently localized. In 37 instances (38%) a true abscess was found and in 10 cases contamination was due to rupture of the appendix during its removal. Appendectomy was performed in 78 cases (80%).

TABLE IX.—*Associated Intraperitoneal Infection—Perforated Appendices*

| Classification | No. of Cases | Per Cent of Group |
|---|---|---|
| Generalized Peritonitis .......... 18 | | 19 |
| Localized Peritonitis ............ 23 | | 24 |
| Abscess ........................ 37 | | 38 |
| Contamination due to perforation on removal .................. 10 | | 10 |
| Not accurately recorded......... 9 | | 9 |

Local antibiotic or chemotherapy, usually 5 Gm. of sulfanilamide, was used in 71 patients (73%). In two instances 100,000 units of penicillin was instilled locally. Of the cases in which this local therapy was not practiced, nine were abscesses, 12 local or spreading peritonitis, and five were appendices ruptured during removal.

Seventy cases (72%) were drained. Drainage was usually by Penrose or cigarette drains to the appendiceal site. Drains were placed also in the right lateral gutter and pelvis in several cases in which these latter areas were actually or potentially infected. The majority of undrained cases were those with local or spreading peritonitis or those in whom the appendix had been ruptured during removal. Only two abscesses were closed without drainage.

Cultures taken at operation add little to the study, with *E. Coli* the predominant organism throughout.

In 71 (73%) of the patients penicillin was administered at an initial dosage level of 100,000 units every two hours. The duration of treatment at this level ranged from one to 26 days with an average of 5.3 days. Twenty of the group received smaller initial dosages of penicillin postoperatively. Six patients in whom contamination of the peritoneal cavity was minimal, including three with appendices ruptured during removal, received no penicillin postoperatively. Twelve of the group were treated with 5 Gm. of sodium sulfadiazine intravenously in addition to the postoperative penicillin.

Complications are listed in Table X. The incidence of pulmonary complications is very low (1%) with only one case of transitory atelectasis. Infection occurred in two McBurney incisions which were not drained and in three right rectus incisions associated with drainage through a stab wound. Pelvic abscesses developed in six cases. Three required surgical drainage and three perforated or subsided spontaneously. Three of the six were diagnosed as a localized peritonitis at the original operation, one as a spreading peritonitis, one an abscess, and in one case the appendix was ruptured during removal. All had received sulfanilamide locally; three had been drained and three not drained.

There were two postoperative gastro-intestinal hemorrhages in the group. One occurred as melena and gross hematemesis in a 73 year old man with widespread peritonitis. He bled down to an erythrocyte count of 1,300,000 before the hemorrhage ceased spontaneously. Studies including roentgenological examination of the gastro-intestinal tract during convalescence failed to reveal the source of the bleeding.

TABLE X.—*Complications—Perforated Appendices*

| Type | No. of Cases | Per Cent of Group |
|---|---|---|
| Pulmonary | 1 | 1 |
| Wound | 5 | 5 |
| Pelvic Abscess | 6 | 6 |
| Thrombophlebitis | 1 | 1 |
| Penicillin Reaction (Urticaria) | 1 | 1 |
| Gastrointestinal Hemorrhage | 2 | 2 |

The second case of hemorrhage resulted in the only postoperative death, a mortality rate of 1% for the ruptured appendices, and 0.12% for the entire group of 815 appendectomies. This patient, an 18 year old male, had a perforated appendix with localized peritonitis. The appendix was removed and the crushed stump was inverted in the cecum without ligation. The patient died of a concealed massive intestinal hemorrhage on his fifth postoperative day. At autopsy the source of bleeding was found to be the unligated appendiceal stump. This unfortunate death must be attributed to this fortunately little used technic which increases the danger of just such a complication.

### COMMENT

It is our opinion, based on clinical impressions, that inclusion of penicillin therapy in our routine postoperative treatment of perforated peptic ulcers and perforated appendices has contributed measurably to the low mortality and low morbidity rates for the two groups. Complications due to spread of the existing infection or development of new infectious processes were almost entirely eliminated. In only one of the two ulcer deaths did infection play a part and this was an overwhelming peritonitis from the start. The one death from appendicitis was in no way related to infection. True, there were several residual pelvic collections in the two groups, but even some of these subsided spontaneously under continued penicillin therapy. Primarily infectious pulmonary complications were rare. The most noteworthy observa-

tion was the complete absence of wound suppuration in the ulcer group. This is in striking contrast to our past experience with these cases and to the incidence of wound infection reported by others.[2,3]

It may justifiably be asked why we have not presented a control series with which to compare our data for a more accurate evaluation of the contribution of penicillin to our results. Such a series is not obtainable. Comparison with similar groups of cases treated at this hospital in the pre-penicillin era introduces too many additional factors which have been added to our routine postoperative regime. These include earlier ambulation and oral feeding, more intensive vitamin therapy, and an increasing use of whole blood plasma, serum albumen, and the protein hydrolysates.

## SUMMARY

1. This report is based on 18 months experience with penicillin as an integral factor in the routine postoperative treatment of perforated peptic ulcers and perforative appendicitis.

2. Penicillin was given parenterally in large doses (usually 100,000 units) at short intervals and maintained at this dosage level for days or even weeks in those cases in which the slightest indication for continuation of therapy persisted.

3. In a group of 42 ruptured ulcers there were two deaths; a mortality rate of 4.8%. There were only two wound complications in the group, neither primarily infectious.

4. There were 97 perforated appendices in a total series of 815 appendectomies. There was one death; a mortality rate of 1% for the ruptured appendices and 0.12% for the entire group.

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# RESURFACING PROCEDURES IN COMPOUND INJURIES OF LOWER EXTREMITIES† *

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In the recent war, military surgery of the extremities dealt with a great number of compound injuries. Most of them were the result of gunshot wounds, mine explosions, etc., and presented a kind of injury seen relatively infrequently in civilian life. These injuries were characterized by extensive destruction of all layers of tissue, both the superficial and deep structures, skeleton and soft tissues alike.

Improved methods of controlling infection and more efficient surgical management were responsible for preserving many severely damaged extremities which might otherwise have been sacrificed. To rehabilitate these extremities and restore them to a maximum of useful function was the task of specially designated Army hospitals. This was accomplished through the combined planning and work of the three reparative surgical specialties—orthopedics, neurosurgery, and plastic surgery.

The cases referred to the Plastic Surgery Section presented extensive deep scarring which was either unstable or in such a location that it precluded any essential surgery on the deep structures. Some cases had temporary skin grafts and others showed indolent ulcerations. In almost 50% of the cases which came to resurfacing, some sort of bone graft to correct nonunion was anticipated. Other procedures for which resurfacing had to be done were osteotomies for malunion, arthrodeses (often combined with bone grafts), tendon transfers, and nerve sutures. These operations required an adequate exposure of the involved structures, and their success depended largely on primary healing of the operative wound. Extensive scar tissue did not withstand such operative trauma. Furthermore, a bone or tendon graft or a nerve suture needed the protection of a well vascularized soft tissue pad and did not do well in a mass of avascular fibrous tissue.

The plastic surgeon's task was two-fold: to supply a stable and adequate tegumental layer and/or to create conditions favorable for major procedures on the deep structures.

The procedures used in accomplishing these ends were:

1) Free skin grafts
2) Flaps
   a) Contiguous
   b) Direct flaps from the opposite extremity, or
   c) Distant flaps from the trunk

To plan the surgical treatment of the individual patient, the simplest possible method was selected which would fulfill the requirements of the case

with a minimum of additional scarring and discomfort.

The main purpose of this discussion is to evaluate the relative merits of each method and its adaptability to specific problems. Since the standard technics are well known, only the fundamentals of the procedures and those modifications which were found to be of substantial assistance will be emphasized.

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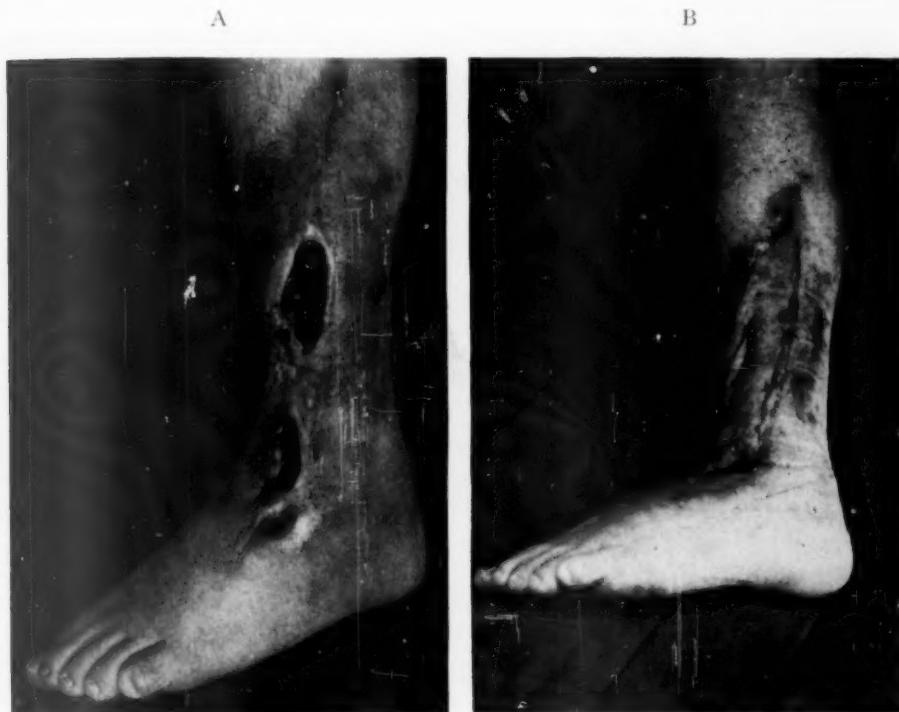


FIG. 1.—The split skin graft. (A) Extensive scarring and ulceration on anterior and lateral surfaces of distal portion of leg and foot as a result of gunshot wound. Comminuted fracture of the tibia and fibula drained for a prolonged period of time. However, fractures healed, and there was no roentgenographic evidence of bony infection. There was spontaneous fusion of ankle joint. (B) The whole scarred area was excised. Two bony cavities filled with granulations were encountered. They were curetted and packed. Defect was covered with split graft which was perforated over packing. Four weeks later when bone cavities were filled with firm granulations, two small split grafts were added. All grafts took well, and no further surgery was necessary.

### FREE SKIN GRAFTS

The free skin graft of intermediate thickness offered the simplest and ordinarily a one stage procedure for treating compound injuries. However, it had a limited field of usefulness. While the grafts took well on a fibrotic base, in the presence of deep scarring, they adhered intimately to the underlying structures. In the absence of a soft tissue pad, particularly over bone, they remained unstable and had a tendency to form indolent ulcerations. They were used, however, in some instances where further exploration of the

area was not anticipated (Fig. 1). Occasionally they were combined with local flaps (Fig. 2). In such instances the flap was reserved for selected locations, like the denuded bone or tendons, the graft covering the surrounding area. Free skin grafts were used routinely with all extremity flaps to cover the secondary defect. Since there was a muscular pad under these donor sites, the grafts offered an adequate and stable cover.

Thin Thiersch grafts were used extensively for temporary resurfacing (Fig. 8A). They could be procured easily, and their source was almost unlimited. Early "skin dressing" of wounds which could not be closed by suture

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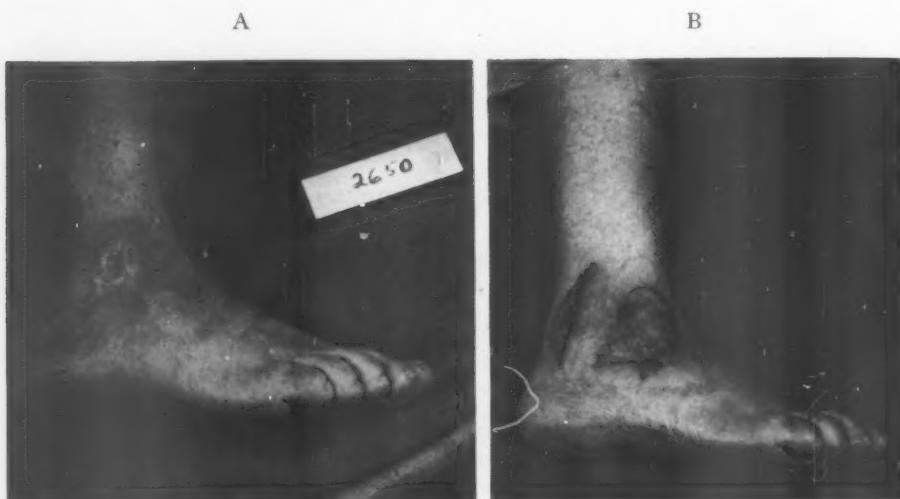


FIG. 2.—Sliding flap combined with a split skin graft. (A) Extensive scarring and chronic ulceration over external malleolus. (B) Scar was excised and exposed bone was chiselled off. Denuded bone was covered with a posterior sliding flap. Posterior donor area as well as remaining anterior portion of defect was resurfaced with a split graft. In this case one procedure, a combination of contiguous flap and free graft, obviated the necessity of a large cross thigh flap which would require multiple stages and prolonged hospitalization.

was an established surgical principle. In the treatment of localized osteomyelitis, so frequent in gunshot wounds of the bone, temporary thin grafts were used after sequestrectomies or saucerizations, though it was apparent that in most of the cases more adequate resurfacing would ultimately be needed.

### FLAPS

A flap was indicated wherever, in addition to the skin, a soft tissue pad was needed. This pad served to replace a mass of avascular tissue and became a protective as well as a vascularizing factor in its new location. Striking examples of this were cases of non-union where a healthy callus began to form as soon as the scar tissue between the fragments was replaced by a soft tissue pad.

Ulcerations or the presence of small granulating areas were not incompatible with the application of flaps. However, inflammatory reaction, drainage,

the presence of deep sinuses, or massive edema were containdications for resurfacing with a flap. In such cases, temporary thin grafts helped to get the extremity in condition for further surgery.

In all cases of osteomyelitic infection, the flap was delayed for a few months after the drainage had ceased, so that a flare-up of the infection would be unlikely. The recurrence of infection underneath a flap leads to sinus formation, chronic drainage, fibrosis and shrinkage of the flap, and may necessitate a repetition of an involved procedure, besides wasting the most favorable source of the flap.

A                                                    B
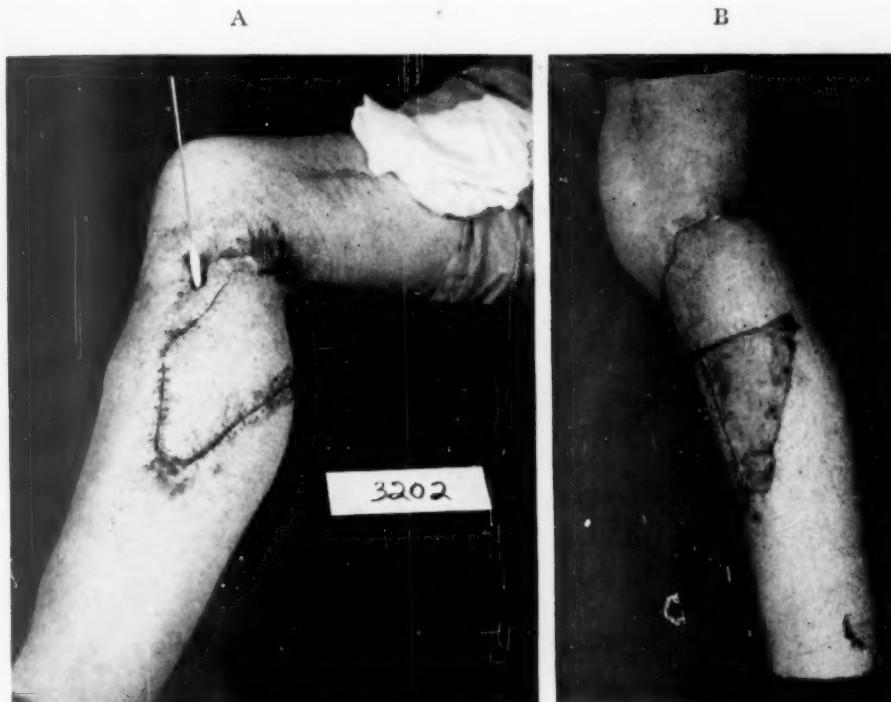


FIG. 3.—Rotation flap combined with iliac bone graft. (A) Post-osteomyelitic bony cavity in a proximal portion of the tibial shaft. Cavity had narrow opening and was completely epithelized with a thin Thiersch graft a few months previously. Surrounding skin was scarred. Delayed rotation flap based in the popliteal region. (B) After temporary skin graft was thoroughly removed and bony walls freshened, the cavity was filled with iliac bone chips. Surrounding scar was excised and replaced with the prepared flap. Donor area grafted.

Closure by approximation after excision of a scar was seldom possible. The size of the scar was often misleading. When the scar was excised and normal tension was restored, the borders of the wound retracted, often doubling or tripling the defect.

CONTIGUOUS FLAPS

A classical method of dealing with excessive tension is a relaxation incision. Such an incision, combined with complete undermining of the bridge of skin

between it and the defect, forms a bipedicled sliding flap (Fig. 2). The sliding flap was particularly applicable to long, relatively narrow defects along the anterior border of the tibia. When the defect was more square or round, a rotation flap was indicated (Fig. 3). Such a flap had only one pedicle, acquired more mobility, and could adapt itself better to depressions and uneven surfaces. It could be rotated 30-120 degrees, as long as any strangulation of the pedicle was avoided.

A    B
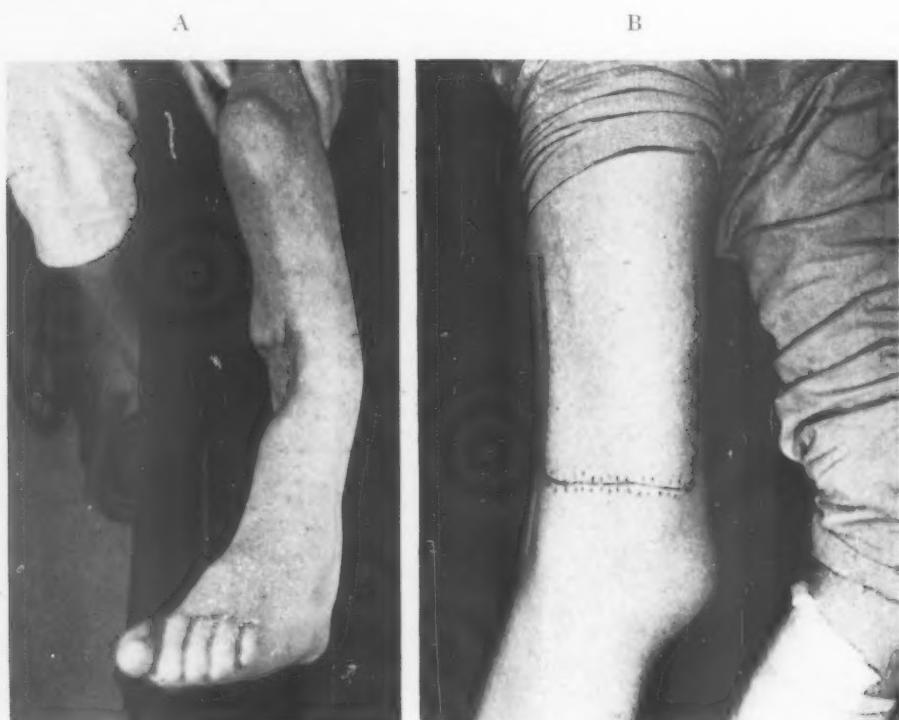


FIG. 4.—Delayed cross thigh flap. (A) Soft tissue loss along medial and anterior surface of mid-third of leg. Non-union of tibia with loss of substance. Adequate resurfacing was essential before a bone graft could be undertaken. (B) Flap on opposite thigh after two stage delaying (17 cm. long and 12 cm. wide).

Rotation flaps were based proximally or distally (retrograde). The latter, as well as the retrograde cross extremity flaps, did not exhibit any unusual difficulty of venous return (Fig. 5b, 5d).

The secondary defect, left by the sliding or rotation flap, was reduced by undermining the posterior skin edge, advancing it, and basting it down with a row of subcutaneous sutures. The remaining part of the defect was always skin grafted. Closure of the secondary defect was not attempted since it would place the flap under tension and so jeopardize its vitality.

The contiguous flap had the advantage of simplicity, limitation of surgery to the injured extremity, and avoidance of uncomfortable immobilization.

However, it could be used only when the skin around the defect was intact
and a large enough flap could be obtained adjoining the defect. Furthermore,
there were a great number of extensive injuries of the lower extremities, com-
bined with non-union of the bone of the distal portion of the leg, where local
flaps had a limited field of usefulness. In this location the blood supply was
poor. Little skin and subcutaneous tissue was available under the best cir-
cumstances, and the secondary free graft was more vulnerable.

C                                                     D
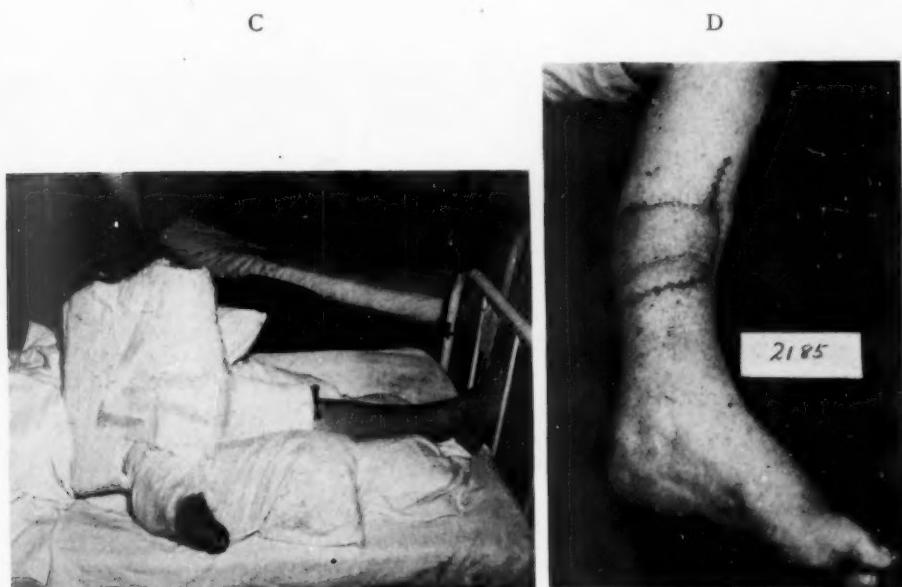


FIG. 4. (C).—Both extremities immobilized in plaster which was not changed or
removed for three weeks until flap was to be severed. Window was made on twelfth day
for inspection. Use of sulfanilamide powder over wound within the layers of gauze helped
absorb secretion and eliminated decomposition. Patient usually required sedation for first
72 hours because of pain in flexed knee. There was little complaint thereafter. It was
helpful to install a Balkan frame from which the extremities could be suspended. Patient
could use trapeze to change position in bed by himself despite weight of plaster. (D) Flap
set in.

### CROSS EXTREMITY FLAPS

Whenever a contiguous flap of adequate size and thickness could not be
obtained, the opposite extremity offered the next best choice as a source of
flaps. In compound injuries of the distal two-thirds of the leg, the cross
extremity flap was most frequently used. In our opinion a direct open flap,
if it could be done according to the principles described below, was preferable
to a tubed flap. Tubing and untubing of flaps and provisions for their transfer
required planning for much larger flaps than the defect called for. The
numerous stages would be time consuming and held the possibility of com-
plications which might jeopardize the whole plan.

The tube was very helpful when a direct transfer was not feasible and when the flap had to be protected from shrinkage and infection during intermediate steps. Immediate skin grafting of the donor area and, if desired, of the undersurface of the pedicle eliminated the granulating surface or kept it to a minimum. With proper dressing technic, (Fig. 4c) maceration was avoided, the discharge controlled, and the postoperative care greatly simplified. Purulent infection was practically non-existent. (It is difficult to evaluate to what extent this was due to the routine use of sulfanilamides or antibiotics.)

A                                                                    B



FIG. 5.—Undelayed cross thigh and cross leg flaps. (A) Defect along medial surface of tibia. Thigh flap 9 cm. long and 7 cm. wide for resurfacing of defect on medial surface of leg preparatory to bone graft for non-union. (B) Retrograde flap on medial surface of leg 10 cm. long and 7 cm. wide for resurfacing of extensive scarring and persistent fissure on sole of foot. Note that flap was allowed to contract in order to fill depth of defect.

In designing our flaps, the aim was always to keep the pedicle as wide as possible. The length of the flap was never more than one and one half times its width (Fig. 4). If feasible, the width of the flap exceeded its length (Fig. 5e). An attempt was always made to bring the recipient area into such approximation to the source of the flap, that the whole flap, or its major portion could be inserted at the first operation (Fig. 5). This plan limited the procedure to one major operation during which all the dissection was performed. It also assured an adequate blood supply to the flap after severance

C



D

E

Fig. 5. (C).—Oblique flap based along popliteal line 10 cm. long and 8 cm. wide to resurface fissure on heel. Heel was previously resurfaced elsewhere with a cross thigh flap. However, flap did not unite with skin on sole of foot, and a persistent fissure developed extending down to bone. (D) Retrograde flap from thigh 13 cm. wide and 12 cm. long for resurfacing of defect on anterolateral surface of leg. (E) Widely pedicled horizontal cross leg flap.

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of the pedicle. The remaining steps were of a minor nature.

This procedure could be followed in the majority of our cross extremity flaps only by utilization of a variety of sites on the leg or the thigh. Medial, lateral and posterior surfaces of the proximal two-thirds of the leg and the

A



B

FIG. 6.—Cross thigh and cross leg flaps for resurfacing of a bilateral deformity. (A) Amputation of all toes bilaterally as a result of frostbite. Scarring and ulceration over forefoot. (B) Undelayed retrograde flap from medial surface of opposite leg was used for right foot.

C



D
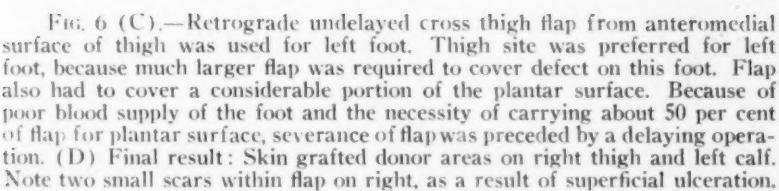
Fig. 6 (C).—Retrograde undelayed cross thigh flap from anteromedial
surface of thigh was used for left foot. Thigh site was preferred for left
foot, because much larger flap was required to cover defect on this foot. Flap
also had to cover a considerable portion of the plantar surface. Because of
poor blood supply of the foot and the necessity of carrying about 50 per cent
of flap for plantar surface, severance of flap was preceded by a delaying opera-
tion. (D) Final result: Skin grafted donor areas on right thigh and left calf.
Note two small scars within flap on right, as a result of superficial ulceration.

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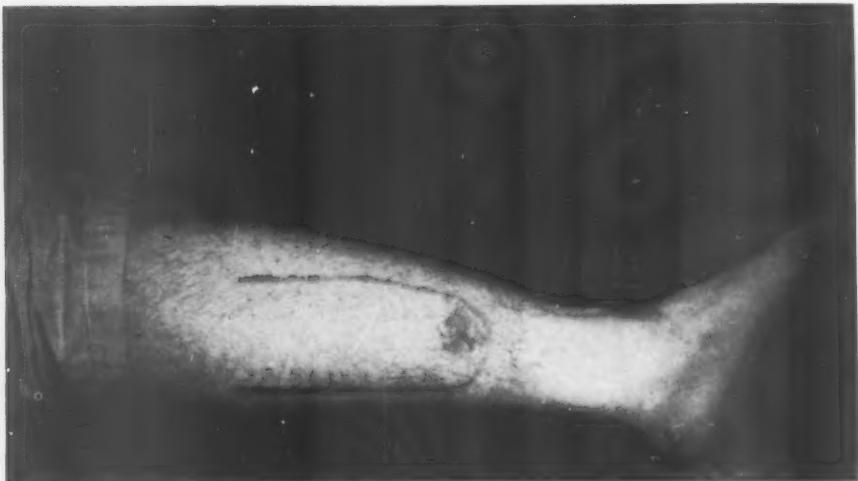
FIG. 7.—Ill-advised flap. Delayed flap for resurfacing of a defect on the opposite leg, (done elsewhere). Note necrosis of tip. This flap was too long and narrow and extended too far distally.

**A**　　　　　　　　　　**B**
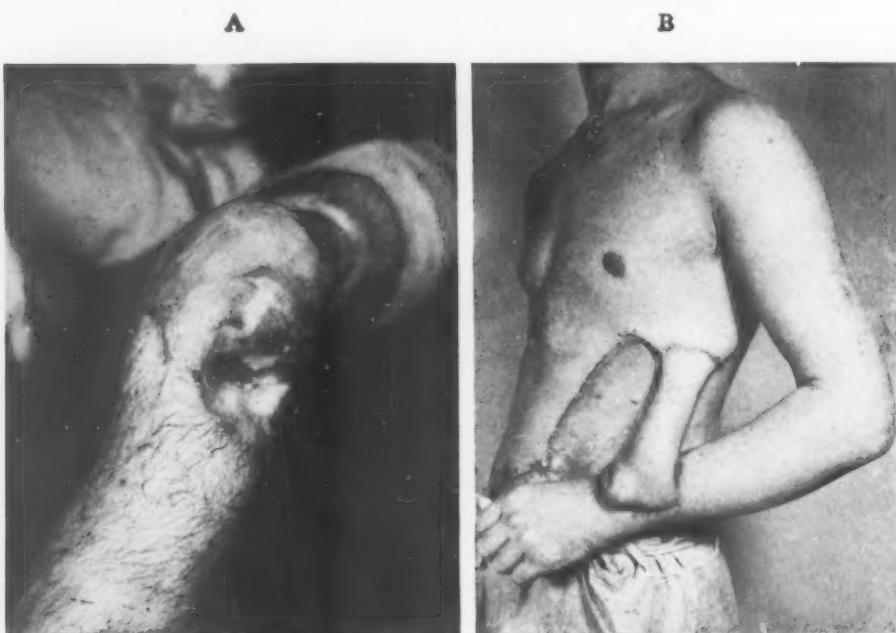


FIG. 8.—Distant tubed flap. (A) Extensive bony defect in the proximal shaft of the tibia with loss of ligamentum patellae. Cavity was covered with a thin temporary skin graft. Anterior surface of patellae and of distal portion of thigh was previously resurfaced with split graft. Knee motion greatly limited due to fibrous adhesions and scarring of quadriceps. (B) Thoraco-epigastric skin tube transferred to forearm. Tube 5" x 9". Note "trap-door" flap on forearm. It was reflected distally, thus doubling surface of attachment of flap. Proximal end of tube had already been delayed.

lateral and anterior aspects of the thigh were frequently used. The presence
of a well developed fascia layer facilitated dissection and offered an excellent
bed for the skin graft. Flaps were never cut across the popliteal space or
along the anterior aspect of the leg where a skin graft would be vulnerable.

C



D

Fig. 8. (C).—Transfer of tube to knee region. Note wide attachment
of tube away from scarred area in order to encourage revascularization of
tube. (D) After final insertion of tube. This procedure required seven minor
and major operative stages.

Experience demonstrated that most of the small or medium sized flaps did
not need to be delayed (Fig. 5, 6b). However, when the flap was large or
whenever there was any doubt about the adequacy of the circulation, delaying
was essential (Fig. 4, 6c).

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Rigid immobilization of the legs in plaster relieved the patient of any acute discomfort after the initial period of 48-72 hours (Fig. 4c). The less the knee was flexed the more comfortable was the immobilization. This consideration favored the use of leg flaps. On the other hand, there was less hesitation in removing large flaps from the thigh than from the leg.

All distant flaps must develop a completely new blood supply before they are detached from their original site. Therefore it was essential to excise all the scar tissue in order to allow the flap to join with healthy tissue. Very small flaps did not do well since they did not have an adequate opportunity to develop a new blood supply. Small defects were enlarged by allowing the surrounding skin to retract or, in some instances, by sacrificing normal skin.

The pedicle was severed in about three weeks. If the final insertion of the flap required any appreciable dissections, it was delayed for seven to ten days after the severance of the pedicle. Otherwise the circulation of the free portion of the flap might have been endangered.

Minor complications of cross extremity flaps were superficial ulcerations as shown in Fig. 6d, or delayed healing at the time of the insertion of the pedicle. These, however, did not jeopardize the results. Major complications, such as full thickness losses were very infrequent. Of 33 cases of cross extremity flaps, whose records were available for review, one case required an additional cross leg flap. The loss involved the proximal portion of a small flap when an attempt was made to insert it at the time of the severance of the pedicle. In two cases, small losses were replaced by local rotation flaps. In a few other cases, a revision of the scar was undertaken in preparation for a bone graft before the patient was referred to the orthopedic department for further surgery.

## DISTANT FLAPS

In several instances neither a contiguous flap nor a cross extremity flap was applicable. The required flap was so large that it could not be taken from an extremity. Defects over the proximal part of the leg along the lateral surface could not conveniently be brought into close approximation with a satisfactory source of flap on the opposite extremity. The desirable donor areas were sometimes damaged in previous operations, or one of the opposite extremities might have been amputated. Removal of the flap from the amputation stump was hazardous, since the remaining skin graft might not withstand the friction and pressure from the bucket of the artificial limb. In cases of ankylosis of the knee joint in the involved extremity, a cross leg flap could rarely be used. In all these instances, a distant flap from the trunk was indicated. It was our opinion that this method should be used only as a last resort, since it required multiple stages, considerable time, and subjected the patient to uncomfortable immobilization.

The tube flap offered the safest and most convenient form for transferring tissue from a distance. When the flap was of moderate size, an oblique abdominal tube was formed which allowed for primary closure of the donor

area. When large tubes were needed, the thoraco-epigastric variety was pre-ferred, and the underlying surface on the abdomen and chest was skin grafted. The tube was then attached to the distal portion of the forearm for migration into its new location. The management of such a case is shown in Figure 8.

In the majority of our cases the resurfacing completed only one phase of the treatment. It was the orthopedic surgeon who most frequently took further responsibility for the rehabilitation of the patient. The plastic surgeon remained available to advise on the precautions necessary to safeguard the flap and to assure primary healing after the operation on the deep structures.

Many of the subsequent complications following bone grafts, arthrodesis, etc. could be traced back either to an inadequate flap or to ill-planned incisions and exposures in the presence of a satisfactory flap. Close cooperation between the specialties produced better understanding of each other's problems and helped to avoid many of these complications.

## SUMMARY

The importance of adequate resurfacing in the rehabilitation of compound injuries of the lower extremities is emphasized. Several procedures are described with particular attention to their comparative merits and limitations in meeting the requirements of individual cases. Skin grafts, contiguous flaps and flaps from the trunk are discussed. Since the cross extremity flap was most frequently used as a preliminary to further orthopedic procedures, its design and essential points of technic are elaborated.

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# UROLOGIC COMPLICATIONS OF LEFT COLON SURGERY *

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WITH THE EVER-INCREASING RECOGNITION of malignancy of the colon in the operable stage and the resultant increase in radical surgery of the large bowel, it is important to draw attention again to a very frequent complication of that type of surgery and to point out several features which may lead to a decrease in the incidence of such complications. It is extremely distressing to both the patient and the surgeon to find, after a presumably excellent extirpation of a bowel segment, that a urinary tract problem is present in the form of urinary leakage from the wound or that the patient is unable to void or has a urinary tract infection. Reports in the literature[1, 3, 5, 6] disclose that there is a wide range of percentage incidence of urinary tract complications following colon surgery, particularly abdominoperineal resection; some surgeons have indicated that *100%* of their cases develop urinary tract problems postoperatively especially those problems referable to vesical dysfunction! On the whole, an incidence of 30% of urinary complications following operations on the left colon, would seem to be average.

On the urologic service of the New York Post-Graduate Hospital, we have seen, in consultation, the more serious of the urinary complications after colon surgery and we feel that a recapitulation of these cases and our observations might be helpful in the management of such problems. In the last 100 cases of left colon surgery, there have been 15 patients with severe complications which necessitated urologic consultation and care. Analysis of the cases shows that three-quarters of the problems occur in males, and also that most of the cases[12] occur in abdominoperineal surgery rather than in operations proximal to the rectum.

### URETERAL INJURY

We believe that the general surgeon is to be congratulated in avoiding more frequent injury to the ureter despite the very extensive and difficult operative procedure involved in abdominoperineal resection. Nevertheless, some observations may be made relative to ureteral injury as witness the following illustrative case, one of two ureteroperineal fistula problems we have encountered in the above series:

**Case 1.** PGH No. J-99386. A 65-year-old man had symptoms of progressive constipation together with ribbon-like stools. Barium colon enema showed an annular obstructing neoplasm. A one-stage abdominoperineal resection was performed with a midline colostomy. There were no particular difficulties encountered during the operative procedure. The abdominal wound healed by primary union. Eleven days after operation, urinary drainage was noticed from the posterior wound which was slowly filling in. The patient was dismissed from the hospital 20 days after surgery.

He came under urologic observation three months after abdominoperineal resection. During this period urinary drainage had persisted from a small opening in the perineum; drainage was moderately profuse and was at times bloody. Intravenous urography showed moderately advanced hydronephrosis in a poorly functioning right kidney; cystoscopy and attempted ureteral catheterization revealed the presence of an impassable strictured area of the right ureter approximately 2 cm. above the bladder with a ureteroperineal fistula at this site.

Right nephrectomy was performed with resultant cessation of urinary drainage from the perineum and complete healing (Fig. 1).

Two important considerations are emphasized by this case: (1) The surgeon is always meticulously careful to dissect and observe the left ureter, but is perhaps less aware of the right ureter because seemingly it is right-sided and situated far from the left colon, the site of surgery. Because of this, there is great danger of inadvertent injury to the *right* ureter, as occurred in this case; the right ureter is not immune to surgical accident and should be as carefully identified and observed as is its corresponding mate on the left. (2) Should ureteral damage occur and resultant urinary drainage appear, *immediate* urologic investigation should be done to establish the source of the drainage. In the case cited above, three months were permitted to pass before

TABLE I.—Urinary tract problems occurring in 100 cases of Left Colon Surgery

| Abdominoperineal Resection. | | | Resection and Primary Anastomosis of Colon. | |
|---|---|---|---|---|
| Number of cases................ | 55 | | 45 | |
| Number of postoperative urinary problems .................... | 12 | { 2 female } 10 male | 3 | { 1 female } 2 male |
| Ureteral fistula ................ | 2 | | | |
| Urinary retention ............. | 8 | | 0 | |
| Urinary tract infection including cystitis ..................... | 5 | | 1 | |
| | | | 2 | |

such investigation was carried out, and during this time, the kidney on the involved side developed progressive hydronephrosis and diminution of function which necessitated nephrectomy. Had the problem been determined at its inception, it might have been possible to avoid nephrectomy by either a plastic procedure on the ureter, or by reimplantation of the ureter into the bladder. Renal conservation or salvage is now a primary object of the urologic surgeon.

Where ureteral injury occurs at the time of colon surgery and is at once recognized, end-to-end anastomosis or repair of the ureteral opening should be made over a splinting catheter, the end of which is passed down into the bladder. At a later date, when healing of the traumatized ureter is established, the catheter may be withdrawn by cystoscopic means. Such a program will obviate later secondary urologic plastic operation or even sacrifice of a kidney.

Be that as it may, it should be a distinct obligation of the surgeon performing colon resection to identify *both* ureters, to dissect them carefully, thus avoiding trauma to either one.

### BLADDER INJURY

Needless to say, where the suspicion arises of bladder involvement in cases of carcinoma of the colon, a preoperative complete survey of the urinary tract must be performed; cystoscopy will in most cases reveal whether vesical

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invasion has occurred. This is of much greater importance in the male, for the interposition of the uterus together with the broad ligament and ovaries in the female renders vesical invasion from colonic malignancy less likely.[3] Where bladder invasion is found either at cystoscopy or during operation, the location of the invaded area will determine whether the situation is "operable" or not. When the dome of the bladder, or its posterior wall is involved, partial resection of the bladder may be performed and the bladder closed preferably about a cystostomy tube, although often the surgeon is able to close the bladder completely, providing urinary drainage via a catheter placed urethrally. Any pocedure wherein a portion of the bladder is resected necessarily adds to the operative risk.

Carcinomatous invasion of the trigonal area of the bladder, the prostate or seminal vesicles produces in most cases an "inoperable" condition and removal of the bowel malignancy is generally impossible. However, it is entirely possible that more radical surgery will make these cases "operable"; abdominoperineal resection of the rectosigmoid together with total cystectomy and removal of the prostate and seminal vesicles may be performed. In such a situation, of course, it would be necessary to transplant both ureters to the left colon above the site of resection. This indeed would be a formidable surgical attempt, but no doubt will be performed frequently in due time.

Deliberate bladder surgery in cases of malignancy of the rectosigmoid, however, is totally different from the inadvertent injury to the bladder wall which may occur incidental to the operative procedure on the colon. In the latter instances, a suture may accidentally be taken through the bladder wall; with subsequent necrosis of the tissue involved in the suture, a small opening appears in the posterior vesical aspect and urinary drainage reveals itself in the wound. Such drainage occurs approximately 10 to 14 days postoperatively and where the bladder defect is not a huge one, conservative management is indicated and spontaneous healing of the urinary fistula occurs. The bladder must be kept in a contracted state, and the urine diverted for a minimum of two weeks following appearance of the urinary drainage. Differentiation of vesical drainage from ureteral fistula must, of course, first be made by urography and cystoscopy.

In our series of 15 cases of urinary complications occurring in 100 operations for left colon malignancy, there was one instance of inadvertent bladder injury with resultant vesicoperineal fistula; spontaneous healing occurred with conservative management.

**Case 2.** PGH No. J-80224. A 63-year-old gardener complained of frequent bloody stools of 3 months' duration. A mass was felt at the tip of the rectal examining finger. Biopsy revealed the mass to be adenocarcinoma of the rectum. A preliminary colostomy was performed, followed one month later by abdominoperineal resection of the rectosigmoid colon. At operation, there was no apparent extracolonic spread of the carcinoma, and no difficulties were encountered in removing the colonic segment. Twelve days following the latter operation, clear urinary drainage appeared from the posterior wound several days after the patient was voiding without difficulty. Intravenous urography was

performed, and the cystogram disclosed urinary drainage from the left lateral superior border of the bladder (Fig. 2). An indwelling urethral catheter was relied upon for constant bladder drainage, and intermittent bladder lavage was performed. No further urinary drainage from the perineal wound was noted, and 18 days after discovery of the vesico-perineal urinary drainage, the urethral catheter was removed with no subsequent drainage or other urinary problem.

### VESICAL DYSFUNCTION

Probably the most distressing and certainly the most frequent urinary complication after pelvic colon surgery is the problem of the bladder which is unable to empty itself and/or which becomes infected. Twelve of the 15 cases in our series were of this character; these cases ranged from severe upper urinary tract infection to serious symptoms of cystitis accompanied by urinary retention and, in four cases, another operative procedure, namely transurethral resection of the prostate had to be performed before "cure" could be accomplished.



FIG. 1.                                    FIG. 2.

FIG. 1. Case 1.—Obstruction to passage of catheter in ureter and extravasation of contrast substance indicating ureteroperineal urinary fistula.
FIG. 2. Case 2.—Cystogram disclosing extravasation of contrast substance from defect in cephalad aspect of bladder.

The majority of these cases occurs where perineal dissection is performed and in males (in our series of bladder dysfunction, 9 out of the 12 patients were male). The reason for the preponderance of males will be seen in the discussion below. The most prevalent theory for explanation of bladder dysfunction is that of injury to the autonomic nervous system during mobilization and excision of the distal colon. Undoubtedly this factor plays an important role in the inability of the bladder to empty itself postoperatively, but one cannot

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ascribe the entire cause to this single factor. Other important etiologic elements are: (1) direct trauma to the bladder, (2) prostatic obstruction, and (3) post-operative sagging of the bladder. It is our belief that no one element can be singled out as *the* cause of the bladder dysfunction seen in these patients, and that all in concert, perhaps with one factor more prominent than the rest, act to prevent normal bladder function postoperatively:
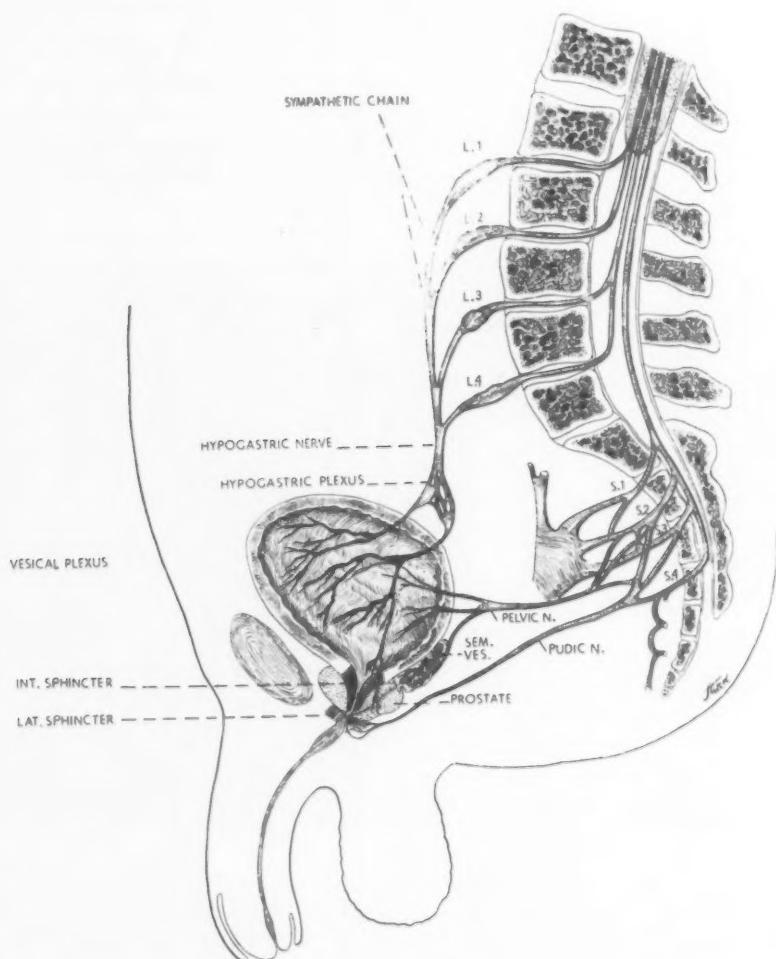


FIG. 3.—Schematic sketch of the nerve supply to the bladder.

1. *Direct violence to the bladder.*—In any procedure in which mobilization of the distal colon is performed, there is bound to be a certain amount of "tearing" of the posterior wall and base of the bladder with resultant edema, which of itself would undoubtedly inhibit normal bladder activity. In the female, obviously, because of the interposition of uterus, broad ligament, tubes, ovaries and vagina, the bladder is less likely to suffer such trauma and the

resultant incidence of bladder dysfunction for this reason alone would be much lower than in the male. All in all, however, trauma to the bladder does not play a major role in postoperative vesical dysfunction.

2. *Nerve injury.*—Postoperative bladder atony is generally ascribed to severance of the autonomic nerves during the operation dissection. The nerve supply to the bladder consists of the presacral nerves (sympathetic fibers arising from spinal cord segments Lumbar 2, 3, 4, 5) and the pelvic nerves



COELIAC GANGLIA

SUP. MESENTERIC GANGLION

INF. MESENTERIC GANGLION

SUP. HYPOGASTRIC PLEXUS
(PRE-SACRAL NERVES)

LAT. SACRAL SYMPATHETIC
GANGLIATED CHAIN

RT. HYPOGASTRIC NERVE

L. HYPOGASTRIC NERVE

BLADDER

PELVIC NERVE BRANCHES
(PARASYMPATHETIC)

SUP. HYPOGASTRIC GANGLION
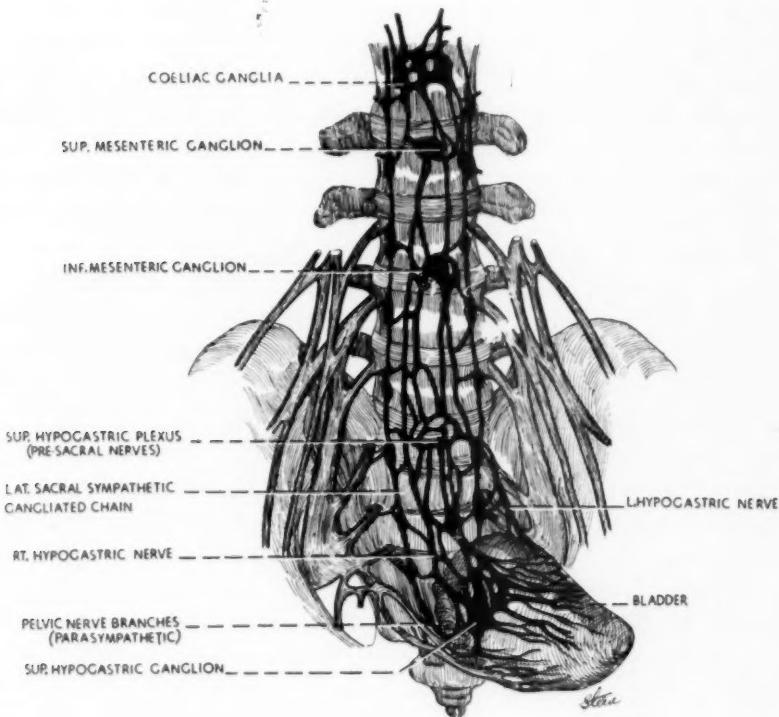
Fig. 4.—Representation of the anatomic distribution of the autonomic nerve supply to the bladder.

(parasympathetic fibers from spinal cord segments Sacral 2, 3, 4) ; these unite to form the hypogastric plexuses which lie on the pelvic floor, one on each side of the rectum. The sympathetic nerves are less important regarding bladder action than are the parasympathetic fibers, the latter having the function of stimulating the bladder musculature to contract (Fig. 3 and 4). Where injury to these nerves occurs, the bladder becomes unable to contract forcefully, becomes progressively atonic, thus inviting infection. In such cases, postoperative cystometric readings show a flattened curve of intravesical pressure with the patient's first desire to void present only after the bladder is filled with very large amounts of fluid.

Dissection of the rectum with great attention to staying close to the rectal wall would perhaps obviate damage to the autonomic plexuses. In this regard, it is interesting to note that Bacon[1] reports low incidence of vesical dysfunction following proctosigmoidectomy; his technic preserves the anal sphincter musculature and, consequently, there is no extensive perineal dissection and formation of a large posterior wound as in the typical Miles abdominoperineal resection. This undoubtedly lessens nerve trauma and thus postoperative bladder function is less likely to suffer.

3. *Posterior sagging of the bladder*—is said by Marshall et al[7] to play a significant part in the patient's difficulty to void postoperatively. Support to the bladder and prostate in the form of the rectum and sigmoid is absent after the colon resection; consequently, the bladder and vesical neck sag backward, thus producing dysuria. This would certainly help to explain why vesical dysfunction is less frequent in the female, inasmuch as support to the bladder would still be given by the broad ligament, tubes and uterus even after removal of the rectosigmoid.

4. *Vesical neck obstruction.*—As we see it, the obstruction to urinary outflow in the form of prostatic intrusion or median bar is the most important determinant in the problem of bladder dysfunction following colon surgery. Even where the patient prior to operation gives no history of difficulty in voiding, the status postoperatively may be completely changed: we now have a bladder musculature which has been weakened by trauma to the nerves supplying it, competing with an obstructive lesion at the neck of the bladder. Whereas preoperatively, the bladder was "compensated" in its ability to force urine out over a relatively unimportant obstruction at the vesical neck, postoperatively, the bladder becomes "decompensated" and is unable any longer to overcome the same obstructive factor. Anatomically, the amount of tissue which acts as an obstruction may be minute, as it was in one case requiring transurethral resection of the vesical neck where 1.6 Gm. of tissue was resected, or on the other hand, true prostatic enlargement may be present as it was in another case where 80 Gm. of tissue had to be removed in order to establish an adequate waterway. The following case will illustrate the characteristic sequence of events where vesical neck obstruction is present:

**Case 3.** PGH No. K-13322. A retired printer, 72 years of age, who gave a history of slight prostatic obstructive symptoms of several years' duration was operated upon for adenocarcinoma of the rectum; abdominoperineal resection was performed. After removal of the routinely used inlying urethral catheter on the fourth postoperative day, the patient was unable to void. During the subsequent week, though he was able to void with some difficulty, a large residual urine remained in the bladder and urologic consultation was requested 15 days after operation. Cystoscopy was performed with findings of a median bar plus very slight intrusion of both lateral lobes of the prostate. Transurethral resection was performed, with removal of six Gm. of prostatic tissue. Two days after the resection, on removal of the catheter, the patient was able to void with a good stream and completely empty the bladder. There have been no subsequent urinary symptoms and examination shows no residual urine.

## MANAGEMENT OF POSTOPERATIVE VESICAL DYSFUNCTION

As is true of almost every problem, prevention would obviate a great deal of distress and in this situation of vesical dysfunction one can, to a great extent, spare the patient much postoperative difficulty. First of all, though the rectal symptoms may be so pronounced as to overshadow every other complaint of the patient, it must be the object of the physician to specifically inquire concerning urinary tract symptoms and to ferret out the presence of any bladder problems. Where a history of urinary difficulty is present, urologic survey and cystoscopy should be done preoperatively. In the presence of obstruction of the vesical neck, transurethral resection should be performed *prior* to colon surgery.

Even in the absence of symptoms suggesting bladder neck obstruction, it might nevertheless be wise to pursue the policy of preoperative cystoscopy, particularly in those male patients where rectal examination shows the prostate to be larger than normal. In many of these patients, cystoscopy will reveal obstruction which should be removed by endoscopic means before the colon lesion is attacked surgically.

Postoperative management commences in the operating room with the insertion of a soft rubber catheter of the self-retaining type. This should be small in calibre, either No. 16 F. or No. 18 F. Because any catheter which is permitted to remain inlying for longer than 24 hours inevitably and invariably leads to urinary infection and because over 90% of these infections are due to coliform organisms, a sulfonamide should be given prophylactically. (We prefer to give either sulfathiazole or sulfadiazine Gm 0.5 every 4 hours with equal amounts of sodium bicarbonate. Sulfathalidine should be administered both pre- and postoperatively.) Bladder lavage with any suitable solution should be done at least three times daily.

In order to overcome the effect of operative trauma to the autonomic nerves supplying the bladder, administration of a parasympathetic stimulant drug is wise; we have found the most effective to be mecholyl bromide in dosages of 200 mg. t.i.d.

After approximately five days of the above regimen, the urethral catheter should be removed. Subsequently, *although the patient may be able to void spontaneously,* he should be catherized at the end of an eight hour period and the amount of residual urine determined. If this amount is greater than 100 cc., the catheter should be reinserted for several more days, and the residual urine determined again at the end of that period of time. Where a large residual urine and difficulty in urination persist, cystoscopic examination should be performed; further therapy, including the possibility of transurethral resection, will depend upon cystoscopic findings.

Attention to the program outlined above, we believe, will be of considerable help in obviating much vesical discomfort to the patient following his colon surgery.

## SUMMARY

Urologic complications of surgery of the descending colon, particularly in abdominoperineal resection are more frequent than is commonly acknowledged, with 15% of the cases in our series sufficiently serious to warrant management by the urologist.

The majority of these urinary tract complications occur in males, and include injury to the ureter with resultant ureteral fistula, trauma to the bladder causing vesical urinary fistula, and vesical dysfunction. The latter is the most frequent of these urinary tract complications. The necessity for immediate and complete urologic investigation is emphasized when urinary drainage appears in the wound, to the end that renal function may be spared in cases of ureteral fistula.

The most important factors productive of postoperative bladder disability are trauma to the pelvic autonomic nerve plexuses supplying the bladder, and obstruction at the vesical neck. A program of management in the prevention of vesical dysfunction is presented, including preoperative cystoscopy where indicated and transurethral resection of the vesical neck obstruction where such is found either pre- or postoperatively.

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# SACROCOCCYGEAL TERATOMATA IN INFANCY
## A REPORT OF SIX CASES *

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TERATOMAS AND TUMORS containing structures of trigeminal origin, duplicating with varying degrees of development almost any tissue or organ in the body. They tend to occur along the long axis of the body, especially at its poles. Teratomas of the sacrococcygeal region are relatively uncommon: less than 100 have been reported in the literature.

In the past 30 years at the Children's Memorial Hospital, seven such tumors have been observed. One of these cases, containing a well formed scapula, was reported by Dr. A. H. Montgomery in 1922.[1] The remaining six cases are now presented.

## CASE REPORTS

Case 1—*History.* J. S., a white girl, 11 months of age, was admitted to the Children's Memorial Hospital January 5, 1935. At birth a soft tumor was noted at the base of the spine extending into the buttocks, on the right more than on the left. This mass had never been tender or inflamed but gradually doubled in size. There was no weakness or loss of sensation in the lower extremities.

*Examination.* Physical examination was essentially negative except for the tumor mass over the lower sacral region extending into the buttocks. It was soft, irregular in contour, and about the size of a grapefruit. The skin over it was tense with bluish discoloration in the midline. The lower extremities were normal. The blood count and urinalysis were normal. Roentgen-ray examination revealed no abnormality in the spine and no bone was seen in the tumor mass.

*Operation.* Under ether anesthesia a transverse incision was made across the tumor, exposing an encapsulated mass. This was dissected free and removed. The defect in the pelvic floor was repaired by suture of the levator ani muscles and the wound closed in layers without drainage. A transfusion of 250 cc. of whole blood was given immediately following surgery. The wound healed well and the patient was discharged on the twenty-first postoperative day.

*Pathologic Report.* The specimen consisted of an encapsulated oval mass, weighing 280 Gms. On the surface was a coiled piece of intestine 20 cm. long with its own mesentery. It contained material having the gross appearance of meconium. The central portion consisted of fat fibrous tissue and small areas of cartilage. One section suggested corpus luteum or adrenal cortical tissue.

Microscopic sections revealed fatty and fibrous tissue with scattered structures resembling adrenal glands, fallopian tube, gastric mucosa, renal pelvis and a fully developed portion of small bowel wall.

A diagnosis of nonmalignant teratoma was made.

*Course.* One year after surgery a mass was noticed in the right buttock at the operative site. This gradually increased in size. Four roentgen-ray treatments were given. On March 13, 1936, the patient was readmitted to the hospital. Examination revealed only the mass described above. The following day the scar and an orange-sized cystic mass were removed. It was rather firmly adherent to the rectum. Another transfusion had to be given.

* Submitted for publication, September 1947.

*Pathologic Report.* The specimen was a firm, 5 x6.5 cm., poorly encapsulated mass, containing cysts, firm fibromyxomatous tissue and areas of pink, softer tissue. One area was soft and bright yellow and another contained cartilage.

The microscopic sections showed columnar cells with a tendency to acinar formation, proliferating fibroblasts, smooth muscle and embryonal fat. The diagnosis was recurrent teratoma with malignant changes.

On June 20, 1936, the tumor had recurred in the same area and was removed again. The patient's family cannot be contacted to discover the outcome of this case but it is presumed that she died of recurrence.

**Case 2.**—*History.* C. Z., an 11-day-old white female was admitted March 4, 1937. At delivery a mass had been noticed in the region of the left hip and back. It had slightly increased in size. The bowels moved frequently and on two occasions blood was passed.
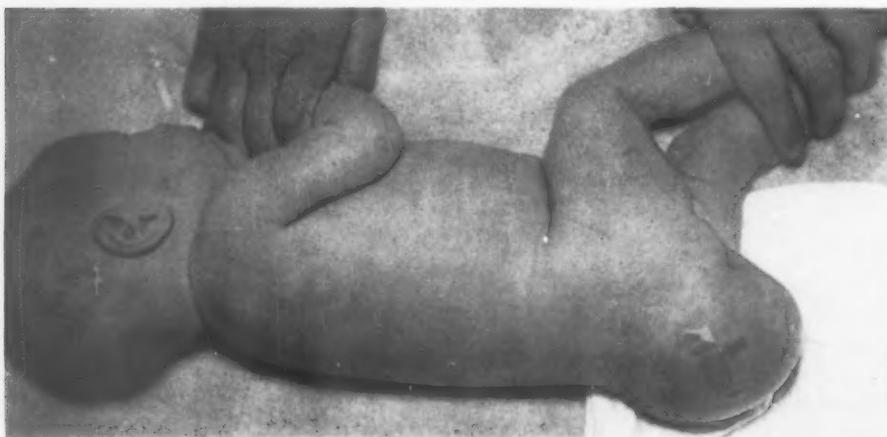


FIG. 1.—Case 2, on admission to hospital.

*Examination.* There was a large cystic mass in the sacrococygeal area, pushing the rectum forward and displacing the anus to the left. (Fig. 1.) The cyst transilluminated and seemed to contain a ballotable mass. Roentgen-ray examination revealed areas of increased density in the mass but no spina bifida. (Fig. 2.) To rule out meningocele, 30 cc. of turbid strawcolored fluid were aspirated from the tumor. There was no sinking of the fontanelle but following aspiration hard masses could be felt in the tumor.

*Operation.* On March 12, 1937, a skin incision was made along the upper border of the mass and the skin flap reflected downwards. The cyst contained yellow fluid and two small hard masses. It was dissected free from its attachment in the region of the sacrum behind the rectum. Tissue in this region was white, hard and gristle-like. The wound was closed in layers and drained.

*Pathologic Report.* The specimen consisted of a cyst wall and two hard masses of tissue.

Microscopic sections revealed brain tissue, cartilage, bone, fatty areolar tissue, fibrous reticulum and sebaceous glands. One section resembled the floor of the lateral ventricle of the brain. Another revealed epithelial structures simulating renal pelvis and tubules.

*Course.* The wound healed and the child was discharged on the thirty-first post-operative day. Roentgen-ray therapy was given.

On December 16, 1937, the child was readmitted for constipation followed by diarrhea, abdominal distention and vomiting of two days' duration. Examination revealed the bladder above the umbilicus. In addition, rectal examination revealed a large, soft, non-tender mass lying in the hollow of the sacrum, pushing the rectum forward. There was a small mass above the operative scar in the sacral region.



FIG. 2.—X-ray of same patient (Case 2) showing areas of calcification in the soft tissue mass.

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Bladder drainage was instituted. Cystograms and intravenous pyelograms revealed a large bladder with some hydro-ureter and clubbing of the minor calyces. The urine contained pus, staphylococcus aureus and *E. coli*. An abscess on the buttock drained spontaneously after the patient had run a febrile course for two months.

Three months later another abscess formed on the back and was drained. The urinary condition had markedly improved. A mild secondary anemia developed. Another course of roentgen-ray therapy was given. Sinuses about the sacral region continued to drain.

The child died at home in 1942, presumably because of the tumor.



FIG. 3.—Cross section of tumor removed from Case 3, showing the typical cystic nature.

**Case 3**—History. P. T., a white girl, age eight months, entered the Children's Memorial Hospital on October 2, 1942, with the history of having had a lobulated, cystic growth in the left buttock since birth. This mass had grown larger and become more superficial, extending into the right buttock. Aside from frequency in stools since birth, the history was otherwise negative.

*Examination.* The examination revealed a multilocular, cystic tumor mass covered with tense skin occupying the left buttock and medial one-third of the right buttock posterior to the rectum. A hemangioma of the left calf was present. The hemoglobin was eight grams; red blood cell count was 3,600,000; white blood cell count was 16,300. The urine was negative.

*Operation.* The day following admission a large multilocular cyst was removed from the sacrococcygeal region. The child was given 110 cc. of whole blood in the operating room. The wound healed well and the child was discharged the seventh postoperative day.

*Pathologic Report.* The specimen consisted of an irregular lobulated mass 11 x9.5 x 4 cm. and weighed 280 Gm. Some portions were cystic; other portions were solid. The capsule was 2 mm. thick. The largest cyst was 4.5 x 4 x 2 cm. and contained thin, yellow fluid. The microscopic sections revealed smooth muscle, cartilage, bone, adipose, tissue, squamous epithelium and nervous tissue. One section revealed glandular tissue with papillary features. The epithelium was pleomorphic with irregular nuclei and disorderly atypical mitosis.

A diagnosis of teratoma with an area of embryonal carcinoma was made (Fig. 3.)

*Course.* On January 10, 1943, the patient was readmitted with the history of recurrence of the tumor above the healed incision three weeks previously. This mass had increased in size and the patient had lost four pounds of weight. Examination revealed a firm, fixed bluish lump the size of a walnut above the incision over the sacrum. This was resected and the wound healed well.

*Pathologic Report.* The specimens consisted of two yellowish gray pieces of tissue 1½ x 1½ x 1½". The miscroscopic section revealed cartilage, adipose and fibrous tissue and glandular tissue with less mitosis than the tumor showed previously.

No trace of this patient can be found. It is probable that she also died of recurrence of the tumor.

**Case 4**—*History.* J. C. was a full term white baby girl. One week after a normal delivery a small tumor had been felt in the left buttock. It grew rapidly in size and at the age of two weeks the child developed urinary retention and was taken to another hospital. Catheterization did not relieve the abdominal distention, so a laparotomy was performed. It was reported that rupture of the bladder and peritonitis were found. The bladder was repaired and drained through a urethral catheter. A small biopsy was taken from a large mass lying in the pelvis behind the bladder. Microscopic sections revealed "nerve tissue having the appearance of brain tissue." Two weeks later the mass in the buttock was removed. The child made a fairly good recovery and at the age of two months was admitted to the Children's Memorial Hospital on May 12, 1941.

*Examination.* The infant was poorly nourished. Her abdomen was distended. A hard mass could be palpated rising out of the pelvis and lying posterior to the rectum. A small, indurated, healed wound was present on the left buttock under which could be felt a large firm mass, extending into the hollow of the sacrum. There was an indwelling urethral catheter. Intravenous pyelograms disclosed an enlarged bladder and hydro-ureters. The hemoglobin was 85 per cent; the red blood cell count was 4,300,000; the urine contained four plus albumin, numerous white blood cells and an occasional red blood cell.

*Course.* Roentgen-ray therapy was given but produced no decrease in the tumor size.

Microscopic examination of a biopsy of the mass in the right buttock revealed dense fibrous tissue containing cystic spaces lined with squamous, low cuboidal and tall columnar epithelium. In some areas there were papillary projections. There was evidence of reaction to irradiation, the bladder function returned to normal and the child was discharged in good condition, although the tumor on the buttock was gradually increasing in size.

On September 12, 1941, the child was readmitted with the acute intestinal obstruction and died 24 hours later.

*Postmortem Findings.* The examination was limited to the reopening of the surgical incisions. There was a large, multiloculated, cystic tumor rising retroperitoneally in the abdomen, 2 cm. above the umbilical level and extending down between the rectum and

sacrum into the buttock. It was attached by firm fibrous adhesions to the coccyx. Cut sections revealed cystic cavities varying markedly in size and in the thickness of their walls. Scattered among the cysts were several white, granular, homogenous nodules and areas of soft, pinkish gray tissue. In addition there was bilateral hydronephrosis, hydro-ureter and ascites.

Microscopic sections showed cystic spaces lined with epithelium similar to those found on biopsy. Some areas resembled gastric mucosa and one section appeared to be pancreatic



Fig. 4.—Case 5, on admission to hospital.
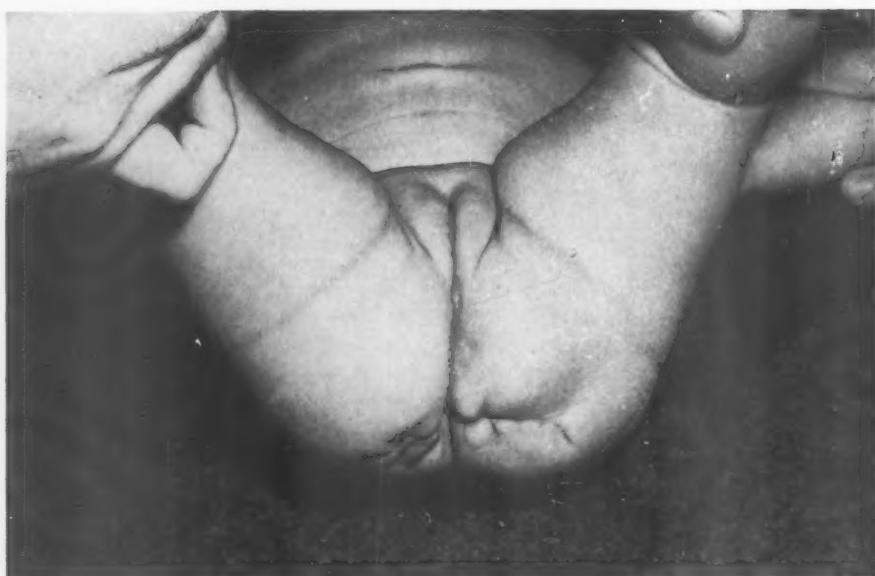


Fig. 5.—Case 5, three months postoperatively.

tissue. There were large aggregates of atypical ganglion cells and nerve fibers in collagenous connective tissue. Peri-aortic nodes showed no metastasis. A diagnosis of teratoma without evidence of malignant changes was made.

**Case 5**—*History.* M. was a white female, one day old, weighing seven pounds, two ounces, admitted to the Children's Memorial Hospital on June 1, 1946. At birth a large tumor attached over the sacrum was noted (Fig. 4).

*Examination.* The infant was normal except for a large, irregular tumor lying over the lower sacral region. It was covered with skin except for a small ulcerated area. Urinalysis and blood count were normal. Roentgen-ray examination revealed no bony pathology in the spine but the tumor mass 8 x 12 cm. could be visualized containing areas of calcification. The diagnosis of sacrococcygeal teratoma was made.



FIG. 6.—Cross section of tumor removed from Case 5.

*Operation.* The tumor was removed the same day. A circular incision was made about the base and the mass dissected free. It extended behind the rectum into the hollow of the sacrum. Considerable bleeding was encountered and the infant went into shock. Rapid transfusion of 250 cc. of whole blood revived the patient and the closure of the wound was completed.

*Pathologic Report.* The tumor measured 12 x 10 x 5 cm. and weighed 320 Gm. It contained cysts and calcified areas at the base. Near the skin surface were dark red lobulated masses and firm round nodules (Fig. 6).

Microscopic sections revealed glial tissue and some areas resembling choroid plexus, fatty tissue with nodules of cornified squamous epithelium and sweat glands with bodies having the appearance of hair. Fibrous tissue contained cells varying in size, shape and staining reaction with some mitosis and occasional giant cells. Other sections revealed cartilage, smooth and striated muscle and pseudostratified columnar ciliated epithelium. A diagnosis of teratoma was made.

*Course.* Recovery was uneventful and the wound healed well. The patient was discharged on the eighteenth postoperative day. At the present time the patient is healthy

and shows no recurrence of the tumor (Fig. 5).

**Case 6**—*History*. J. T., a 3½ month old white female was admitted to the hospital October 26, 1944, for constipation due to a congenital anal stricture and a hard mass in the right buttock present for three days.

*Examination*. There was an anal stricture and a rectovaginal fistula. The right buttock was swollen, hard and tender and one week later pus drained spontaneously from the intergluteal fold. Two months later the abscess reformed and was incised.

*Course*. A draining sinus remained in the sacrococcygeal area. Frequent rectal dilatations were necessary. On July 26, 1945, a colostomy was performed. A year later the child was readmitted.

*Operation*. On July 31, 1946, an incision was made in the sacral region and a cystic structure was found imbedded in dense scar tissue. This extended down toward the sacrum and was dissected free. Attached to it was a second, smaller cyst which was likewise removed. Some clear fluid escaped which resembled spinal fluid. The wound was closed in layers without drainage.

*Pathologic Report*. The specimen consisted of a dumbbell-shaped piece of tissue 5 x 2 cm. containing a cyst with a smooth lining and filled with milky fluid. Microscopically the cyst was lined with stratified squamous epithelium surrounded by dense fibrous tissue. Other areas showed columnar epithelium, loose myxomatous connective tissue and nerves. One area contained ganglion cells imbedded in a fibrillar network resembling neurologial tissue. A diagnosis of a benign teratoid tumor was made. Because no structures of entodermal origin could be found, the tumor more closely resembled a dermoid cyst.

*Course*. The wound healed well and there has been no recurrence to date. The rectovaginal fistula is to be repaired soon.

### DISCUSSION

*Incidence*.—Calbet[2] stated that congenital tumors of the sacrococcygeal regions occur once in 34,582 births. Teratomas represent only a very small percentage of these tumors.

The tumors are thought to be invariably present at birth and about 90 per cent of them are recognized at that time. Very few remain unnoticed until adult life. A large percentage of the patients are stillborn or die shortly after birth. Because of their size, these tumors may cause dystocia.[3]

Chaffin[4] reports that 75 per cent of the patients with these tumors are females. In our series all six of the cases were female.

In the past 30 years there have been a little over 600 tumors examined pathologically at the Children's Memorial Hospital. Seven of these were sacrococcygeal teratomas, giving an incidence of approximately one per cent of all tumors in this hospital.

*Origin*.—The origin of those tumors is the only really controversial aspect of teratology. Two main theories have been advanced.

1. Parthenogenic development of the individual's primitive germ cells might give rise to these tumors as is suggested by the experimental work of Bosarus[5] with stimulation of unfertilized frog ova. These germ cells migrating from the primitive streak of the genital ridge could lodge in the sacrococcygeal region. Similarly, in early embryonic life a blastomere resulting from segmentation might begin its own development remaining attached to the main embryo and becoming incorporated in it. If the former occurred, the teratoma

would represent an offspring while in the latter case it would be a twin. It is easy to believe that sacrococcygeal teratoma are rudimentary organ masses representing an ill-developed pygopagus twin.

2. Other authorities believe that these tumors are not fetal implants but arise primarily from cells already present in the sacrococcygeal region in normal embryonic development such as the postanal gut and the neurenteric canal. The close approximation of nervous, intestinal, bony and connective tissue elements in this region is supposed to explain the development of tumors containing structures from all three germ layers.[2]

Chaffin suggests that temporary adhesions between the fetal rump and the amnion may cause formation of teratomas.

*Pathology.*—Teratomas are usually lobulated tissue masses with cystic and solid areas and may contain tissue or malformed organs representing any structure in the body. The most common contents are epithelial lined cysts, connective tissue, ganglion cells and other nervous elements, intestinal mucosa, bone and cartilage. Infrequent tissues are liver, pancreas, kidney, testicle, ovary and chorionic epithelium. Malignant changes will be discussed below.

*Clinical Features.*—Teratomas of this region always have their origin retrorectally and are attached to the coccyx or sacrum.[6] From there they usually grow downward and posteriorly into the buttocks, displacing the anus forward and to one side. They may also extend upward behind the rectum into the abdominal cavity.

The tumors vary in size from a scarcely noticeable lump to a huge mass interfering with bodily function. They are covered with skin but often have ulcerations or fistulae. They may be cystic or solid but usually contain areas of both. Bone may be felt within the tumors and occasionally peristalsis can be observed. Upon stimulation, muscular twitching may be present.

Aside from local examination, it is important to examine the abdomen for evidence of extension of the mass producing urinary or bowel obstruction. Rectal examination will reveal the extent of pelvic growth and the degree of fixation to the rectum. Roentgen-ray is helpful in showing the presence of bone or teeth and in determining spinal development. Aspiration of cystic areas in the tumor is of doubtful help and often leads to infection and fistula formation. Other congenital anomalies are frequently present.

*Differential Diagnosis.*—Other causes of a mass in the sacral region may be meningocele, hernia, abscess, chordoma, dermoid, lipoma, myoma, angioma, myeloma, sarcoma, tuberculosis of sacrum or rectal carcinoma. The last few would be extremely rare in infants.

An accurate diagnosis is necessary in order to determine the proper treatment.

DeVeer and Browder[7] have emphasized several points to differentiate a teratoma from a meningocele. The latter is smaller and does not increase in proportion to the infant growth as does a teratoma. A meningocele is covered by a translucent membrane whereas a teratoma is covered with skin. The

rectum is not often displaced by a meningocele but it is by a teratoma. There is usually evidence of communication between a meningocele and the spinal canal such as expansion of the tumor with coughing and crying or bulging of the fontanelle upon compression of the tumor. Neurologic signs in the lower extremities are more often associated with a meningocele. A roentgenogram of the spine showing spina bifida, also suggests meningocele.

The possibility of the tumor being a rare type of hernia may necessitate a barium meal study to demonstrate continuity of the bowel in the abdomen and in the tumor.

*Complications.*—1. Malignancy—Sacrococcygeal teratomas develop malignant changes in about 15 per cent of the cases. In 1942 Lisco[8] collected 12 cases of malignancy from the 72 teratomas reported up to that time. In our own series, cases I and III contained definite malignant elements and developed local recurrences of the tumors.

Usually only one tissue of the teratoma becomes malignant. This resembles a sarcoma as to the method of spread and tendency to local recurrence.[9] Pathologically, however, the malignant areas usually are either papillary carcinomas or neoplasms of neural origin.

Rapid growth of a teratoma does not necessarily indicate malignancy because growth of the tumor usually parallels that of the child. The presence of well-formed bony structures, muscular twitching or bowel with peristaltic activity indicates a benign tumor.[10]

2. Ulceration, infection and fistula formation may develop as occurred in case II and case VI.

3. Obstruction of the rectum or lower urinary tract may occur if the tumor expands in the hollow of the sacrum. This has been noted frequently in medical literature[11, 12, 13] and occurred in case II and IV.

4. Very rarely hypersection of some endocrine gland in the teratoma may produce generalized effects. Rhoden[13] reported a case of precocious sexual development which he thought was due to the secretion of the adrenal cortical tissue in the teratoma.

5. The position and large size of some teratomas may become a nuisance and discomfort. A case reported by Brines[14] had a very large tumor containing rudimentary arm and hand bones that made sitting or walking quite difficult.

*Treatment.*—It is agreed that complete excision of the tumor as early as possible is the treatment of choice. More and more cases of successful removal of teratomas have been reported in the past few years. Operation in the first year of life gives better results as to recurrences and mortality than if surgery is postponed until later life.[4] Postoperative radiation therapy may also be given especially if pathological examination reveals malignant elements.

Pearse[9] emphasizes that the posterior approach is the best because: 1) complete removal of the tumor with resection of the coccyx, if necessary, is more easily accomplished; 2) the peritoneal cavity is avoided; 3) hemorrhage is

controlled more readily; 4) local recurrences in the scar are easily seen and treated. All the cases operated upon at this hospital have been approached posteriorly.

It is interesting to note the degree of shock that usually accompanies the removal of these tumors. Some authors mention that shock seemed out of proportion to the blood loss.[10, 12, 15] The reasons for this may be several. A large vascular bed is being removed. The region from which the tumor is removed is normally quite vascular and hemostasis is difficult. Also, the degree of blood loss in infants is deceptive. A few blood-dampened sponges may represent a large fraction of the baby's blood volume.

It will be noted that in several of our cases a transfusion was necessary during or immediately after the operation. In case V the infant would have succumbed were it not for rapid replacement of blood loss. In this case a transfusion of 250 cc. of blood was given. Considering the weight of the patient, this represents almost a complete replacement of the total blood volume of the infant.

It has been our practice in all such major procedures to insert a cannula into the long saphenous vein at the ankle and attach to it intravenous tubing and a three-way stopcock to which is connected a 50 cc. syringe and a Salvarsan flask with a Murphy drip tube. During the operation physiologic saline solution is allowed to drip slowly to keep the system open. If necessary, citrated whole blood can be poured into the flask and pumped into the patients' vein quite rapidly by means of the syringe.

### SUMMARY

1. Six previously unreported cases of sacrococcygeal teratomas are presented. All of these were females below the age of one year. Removal of the tumor was attempted in five cases. Malignancy and recurrence occurred in two cases and probably a third. One child died as the result of pressure of the tumor causing urinary and bowel obstruction. Two cases are living and well one year after surgery with no evidence of recurrence.

2. Some clinical aspects of these tumors are reviewed with emphasis on treatment by early and complete surgical excision via the posterior route.

3. A well-known but not widely used method of giving a rapid, often life-saving, transfusion during operation is described. In the removal of these tumors as well as many other major operations on infants the survival of the child may depend on the ability to replace rapidly a serious blood loss.

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# TEMPORARY INTERRUPTION OF THE SYMPATHETIC IMPULSES TO THE HEAD BY INFILTRATION OF THE CERVICAL SYMPATHETIC TRUNK [*]

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INVESTIGATION OF THE GROSS ANATOMIC relations of the cervical and upper thoracic portions of the sympathetic trunk was undertaken in an attempt to evaluate the various methods of injection for interrupting the sympathetic impulses to the head. Thirty-three cadavers were dissected to determine the typical relations of these parts of the sympathetic nervous system. These observations have been correlated with those made during injections by various methods to block the flow of sympathetic impulses to the head.

Several methods have been described by which the flow of sympathetic impulses from the upper thoracic and lower cervical segments may be interrupted temporarily by injection of various anesthetic agents.[1-6] Most of this work has been stimulated by the need of satisfactory therapeutic measures for vasospastic diseases of the upper extremities. Such transient interruption of sympathetic impulses not only is valuable therapeutically but is of aid in predicting the reaction to surgical interruption of the pathways in question.

Since, in blocking this portion of the sympathetic outflow, the usual goal has been to produce temporarily the conditions present in a sympathectomized extremity, the various methods of injecting the inactivating solutions have been directed toward the cervicothoracic ganglion. This is the most strategic point to attack in order to cut off sympathetic impulses to the upper extremity by such an injection. This ganglion also is a point through which the majority of the sympathetic impulses to the head must pass (Fig. 1), although only a small percentage of such impulses is relayed to ganglionic neurons at this level. Therefore, it is not surprising that, in those diseases which respond favorably to interruption of the sympathetic nerve supply to the head, a technic identical to that employed in blocking sympathetic impulses to the upper extremity generally is used.

A review of the neuro-anatomy involved in the transmission of the impulses is essential for an adequate estimation of the problem. The majority of preganglionic fibers which carry sympathetic impulses to the head issue from the central nervous system via the anterior roots of the lower cervical and upper thoracic spinal nerves (Fig. 1). There is evidence that a few such fibers arise from as low as the fifth or sixth thoracic segment[7] and probably many preganglionic fibers emerge in the lower cervical nerves in a large percentage

of cases. The latter undoubtedly are of considerable importance in transmitting sympathetic impulses to the head. Most of these fibers destined to transmit impulses to the head ascend the sympathetic trunk to terminate in the superior cervical ganglion. However, some such fibers pass through this ganglion to synapse on scattered small nests of nerve cells located in close relation to the large arteries. The nerve impulses upon reaching the superior cervical ganglion or other peripheral cell station are relayed via postganglionic fibers (Fig. 1) to the effector units, i.e., a smooth or cardiac muscle or gland cells.
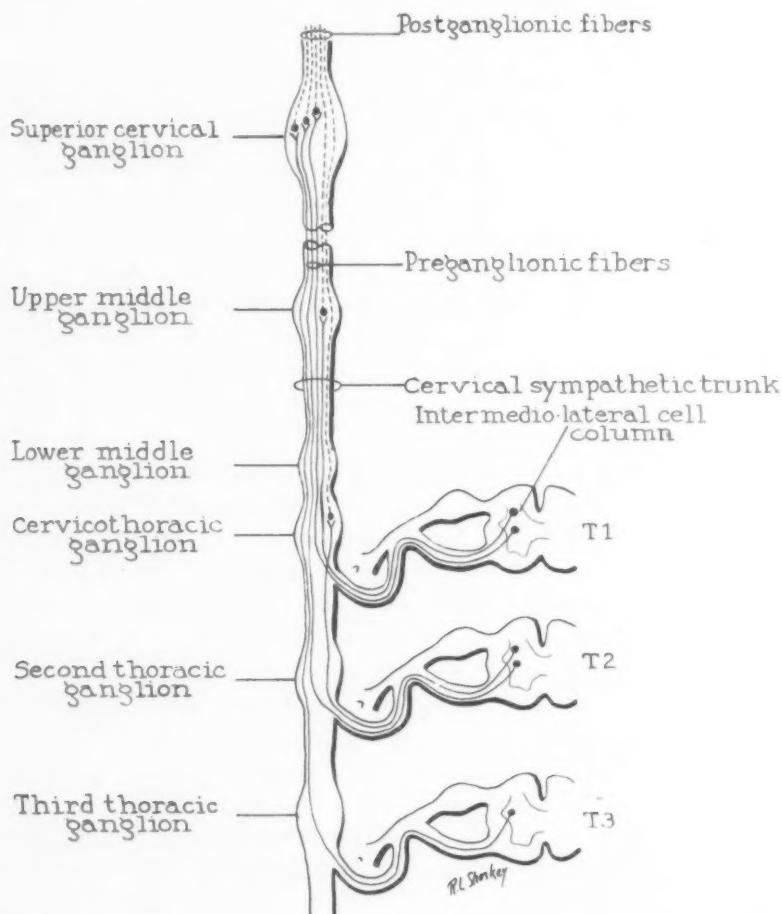


FIG. 1.—Diagram showing synaptic relations of sympathetic fibers to the head.

The postganglionic fibers of the superior cervical ganglion as well as a few postganglionic fibers from more inferiorly located ganglia, a small number of accompanying sensory fibers, and the few preganglionic fibers which pass through the superior cervical ganglion form practically all the fibers of the external and internal carotid plexuses and their subsidiary plexuses. These fibers supply the blood vessels of the face, scalp and most of the brain as well

as the other smooth muscles and many of the gland cells of the head. The majority of the postganglionic sympathetic fibers for the head, which do not arise from cells of the superior cervical ganglion, have their origin in the upper middle cervical ganglion; a smaller number arises in the lower middle cervical ganglion, and still fewer from the cervicothorocaic ganglion (Fig. 1).



Superior cervical ganglion

4.87 cm.

0.5 cm.

6th cervical transverse process

Upper middle cervical ganglion

40 cm.

Lower middle cervical ganglion

Vertebral artery

Cervicothoracic ganglion

Second thoracic ganglion
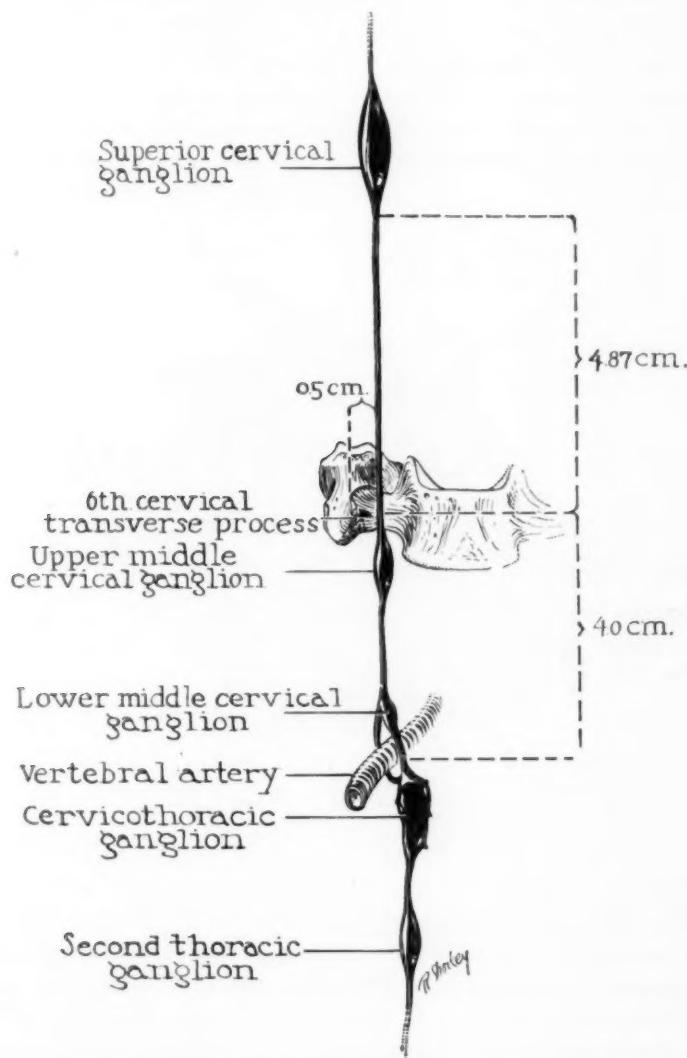
FIG. 2.—Diagram showing average distance of superior cervical and cervicothoracic ganglia from transverse process of sixth cervical vertebrae and average distance of sympathetic trunk from the lateral aspect of the sixth cervical transverse process.

The postganglionic fibers from the upper and lower middle cervical ganglia and the cervicothoracic ganglion with the preganglionic fibers for the middle cervical ganglia and the superior cervical ganglion and a few sensory fibers

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form the major part of the cervical portion of the sympathetic trunk. Some postganglionic fibers for the head, as those of the common carotid plexus, extend upward in close relation to the common carotid artery, and a few travel superiorly along the vertebral artery and terminate in its area of distribution. Most of the impulses which travel along the common carotid and vertebral plexuses as well as those which traverse the cervical sympathetic trunk pass through the cervicothoracic ganglion.

Thus, it is obvious that injection of an anesthetic agent about the cervicothoracic ganglion is an effective method of blocking the sympathetic impulses to the head. It interrupts not only most of the impulses which travel via the cervical sympathetic trunk but also many of those passing along the common
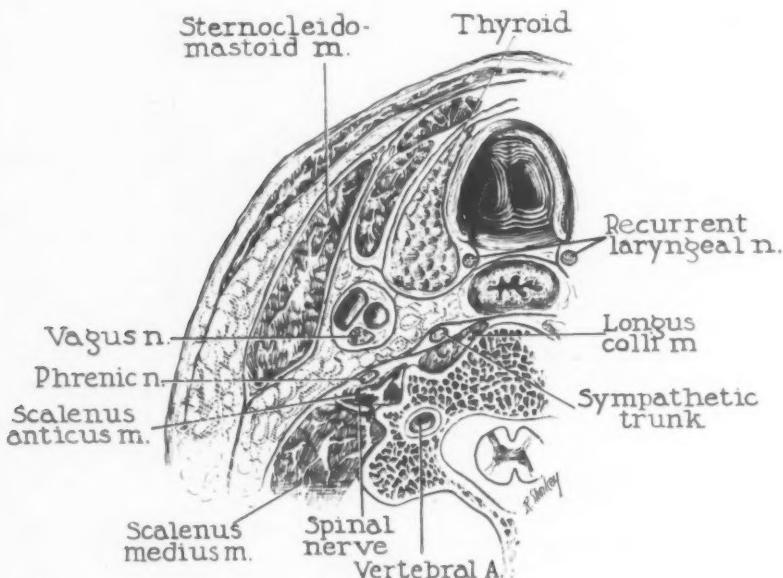


Fig. 3.—Cross section of neck showing relations of sympathetic trunk.

carotid and vertebral plexuses. However, most of the fibers which form the intracranial extension of the cartoid and vertebral plexuses undoubtedly join them as segmental branches from the upper part of the cervical portion of the sympathetic trunk.

Although infiltration of the cervicothoracic ganglion is a benign procedure, it seems less so to the patient than injection of the sympathetic trunk at a higher level and actually is accompanied by several potential complications not shared by the latter method. These include, principally, puncture of the apex of the lung, trauma to a portion of the brachial plexus with subsequent pain in the upper extremity, neck, or thorax, and puncture of the large vessels of the lower portion of the neck and upper part of the thoracic regions.

The sympathetic impulses to the head can be efficiently interrupted temporarily by injection of procaine hydrochloride or other suitable anesthetic agent about the cervical portion of the sympathetic trunk. Such an injection can be done relatively painlessly. The greater ease with which the cervical sympathetic trunk can be infiltrated is an advantage. It can also be done with speed and exactness because of certain anatomic relations. It should be noted that the close approximation of the cervicothoracic ganglion to the posteromedial aspect of the vertebral artery and to the subclavian artery almost completely obviates its actually being injected without transfixing one of these vessels with the needle. The various technics described for blocking the impulses which pass through the ganglion actually are methods of infiltration. The chances for occurrence of complications are reduced by introducing
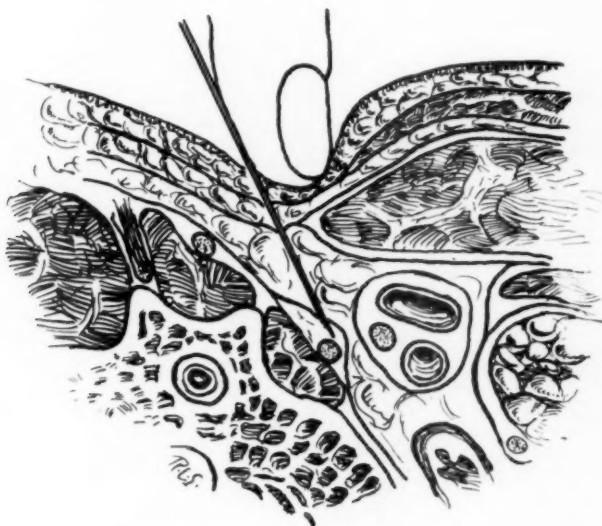


FIG. 4.—Method of palpation of tubercle of transverse process
and insertion of needle.

the solution at a comparatively high level as described by de Sousa Pereira[5] and Caldwell and Broderick.[6] However, this also reduces the effectiveness of the block as far as the upper extremity is concerned unless a relatively large amount of the anesthetic agent is used. The average distance of the upper pole of the cervicothoracic ganglion from the middle of the anterior surface of the sixth cervical transverse process in our anatomic studies was found to be 4.0 cm. on the right and 4.2 cm. on the left (Fig. 2). This distance ranged from 2.7 to 4.8 cm. on the right and from 3.0 to 4.9 cm. on the left.

The principal factor in favor of successful inactivation of the cervical sympathetic trunk by injection is the relation of this part of the sympathetic trunk to the carotid tubercle and the anterior tuberosity on the transverse process of the fifth cervical vertebra. Examination of other anatomic relations

in this area demonstrates amply why this technic is uniformly successful. The sympathetic trunk at the level of the fifth and sixth cervical vertebrae lies on the longus colli muscle, medial and slightly anterior to the fibers of the scalenus anticus muscle in a small compartment formed by the splitting of the pre-vertebral fascia. It is posteromedial to the carotid sheath and its contents (Fig. 3). The latter structures can be palpated easily at this level just deep to the anteromedial margin of the sternocleidomastoid muscle. It is a simple matter to retract the contents of the carotid sheath laterally and palpate the carotid tubercle of the tuberosity on the anterior surface of the transverse
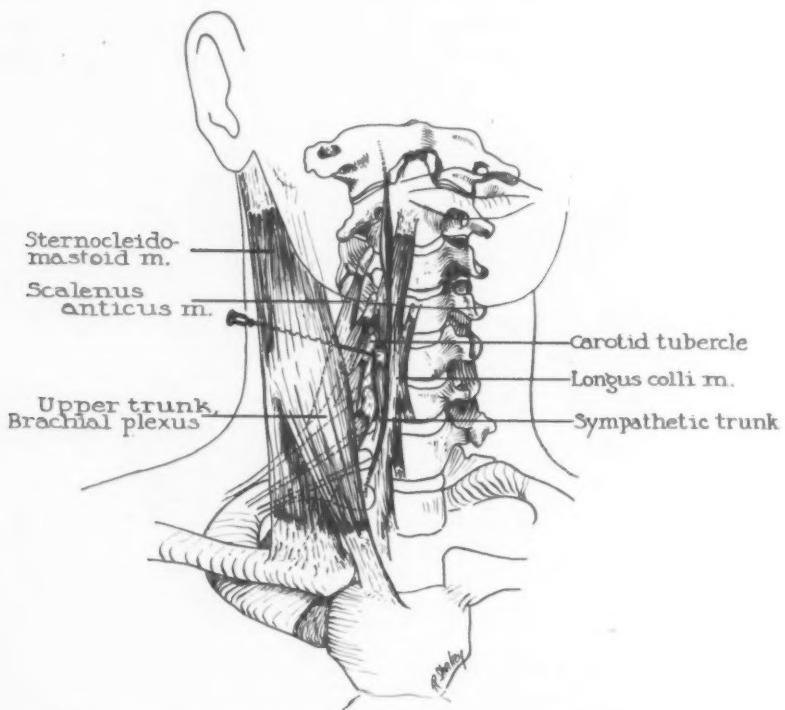


FIG. 5.—Diagram showing relationship of the needle to the sympathetic trunk and adjacent structures.

process of the fifth cervical vertebra. Frequently, it is even easier to palpate these tuberosities by retracting the sternocleidomastoid muscle and the contents of the carotid sheath medially (Fig. 4). It should be stressed that at this level the sympathetic trunk is separated from the vagus nerve by the relatively tough carotid sheath and part of the prevertebral fascia, and from the phrenic nerve by the latter fascia as well as the fascia of the scalenus anticus muscle. The recurrent laryngeal nerve also is well isolated from the sympathetic trunk. When the upper middle cervical ganglion is present, as it has been in approximately 75 per cent of the bodies examined, it lies at or slightly below the sixth cervical transverse process in the majority of instances. It should also be

pointed out that the roots of the brachial plexus and the vertebral artery at this level are safe from injury by a penetrating needle because of their separation from the sympathetic trunk by the transverse process. The inferior thyroid artery is medial to the sympathetic trunk at the level of the sixth cervical transverse process, having crossed behind the trunk at the level of the seventh cervical segment.

In all 66 dissections the sympathetic trunk lay on the longus colli muscle anterior to the carotid tubercle. The average distance of the trunk from the lateral margin of this transverse process was 0.50 cm. on the right and 0.44 cm. on the left (Fig. 2). This measurement ranged from 0.1 to 1.2 cm. The average distance of the lower pole of the superior cervical ganglion from the middle of the sixth cervical transverse process was 4.87 cm. on the right and 4.73 cm. on the left (Fig. 2). This distance varied from 3.9 to 6.9 cm. on the right and from 3.2 to 6.0 cm. on the left. In 50 of the 66 dissections, the anterior tuberosity (carotid tubercle) of the sixth cervical vertebra was more prominent than the anterior tuberosity of the fifth cervical vertebra. In the remainder, either the process of the latter segment was the larger or they were so nearly equal in size that either might have been palpated with equal ease. It is recommended that the injection be done at the level of the most easily palpable tuberosity.

It is evident from the anatomic data collected that the tuberosities of the transverse processes of the fifth and sixth cervical vertebrae are ideal landmarks to utilize in blocking the sympathetic impulses to the head. The trunk at these levels may be approached from a point immediately anterior or just posterior to the sternocleidomastoid muscle. The former may be referred to as the anterior and the latter as the anterolateral approach to the cervical sympathetic trunk. In practice it has been found that the anterolateral approach usually is more satisfactory. The reverse may be true if the sternocleidomastoid muscle is exceptionally wide and well developed. The injection is facilitated by having the patient assume the supine position with the head flexed and turned slightly to the opposite side. This makes the bony landmarks easily accessible to the palpating finger even in an obese person. Flexion of the head increases the ease with which the carotid sheath and its enclosed vessels and nerves may be retracted and diminishes the discomfort of deep palpation in this region. Thus, the sympathetic trunk is made readily accessible to injection without danger of penetrating the vessels of the neck or the more medially located trachea, esophagus and thyroid gland.

In a slender patient the entire procedure may be performed with a small hypodermic needle or only a skin wheal may be made with this type needle followed by insertion of a 21 gage venous puncture needle. The skin wheal usually is made along the posterior border of the sternocleidomastoid muscle opposite the fifth or sixth cervical transverse process. The needle is then inserted and advanced until it is in contact with the lateral surface of the tip

of the transverse process, then withdrawn slightly and reinserted along the anterior surface of the tuberosity (Fig. 5). The injection is performed at a depth of approximately 0.5 cm. from the lateral extent of the transverse process. Needless to say, prior to injection, aspiration should be attempted to ascertain that a blood vessel or the subarachnoid space has not been entered. Owing to the oblique direction of the intervertebral foramen in the cervical region, it is practically impossible to insert a needle into the subarachnoid space from the site of injection along the posterolateral border of the sterno-cleidomastoid muscle unless it is directed upward as well as medially. This need never be done. It is much more likely that this space might be entered by the anterior approach. In either case the importance of preliminary aspiration should never be forgotten. The injection may be done, but usually with less ease and with more discomfort to the patient by retracting the sterno-cleidomastoid muscle and the carotid sheath and its contents laterally, and the trachea or larynx, esophagus and thyroid gland medially. Blocking the cervical sympathetic trunk by this anterior approach, as well as by the anterolateral approach, is made easier by performing the injection at the level of the most prominent tuberosity on the anterior surface of the cervical trans-verse processes. At either level and with either approach the most important step in the entire procedure to insure a successful injection is that the bony landmark be well identified with the palpating finger before the needle is inserted. A typical Horner's syndrome usually appears after injection of from 3 to 5 cc. of a one per cent solution of procaine hydrochloride. However, to prolong interruption of the sympathetic impulses, 8 to 10 cc. may be injected. If the latter quantity is used, it is not advisable to do a bilateral block because there may be dyspnea and palpitation due to some infiltration of the phrenic and vagus nerves.

This technic has been used approximately 350 times on a total of 205 patients over a four year period and rarely has it failed to produce a well defined Horner's syndrome. Also in no instance has there been a sequel of any significance. Occasionally, a patient will complain of pain when the needle is inserted because of irritation of a nerve of the cervical or brachial plexus. Hoarseness, due to concomitant infiltration of the recurrent laryngeal nerve, is encountered infrequently. It should be remembered that the injection may cause a slight tissue reaction, and after three or four infiltrations, if fairly large quantities of the anesthetic agent have been used, the patient is likely to complain of soreness about the site of injection. The local increase in vascu-larity accompanying the inflammatory reaction, as well as the hypertrophy of adjacent lymphoid tissue, may slightly complicate a surgical procedure on the cervical portion of the sympathetic trunk if this follows a series of injections.

In conclusion, it may be stated that infiltration of a suitable anesthetic agent about the sympathetic trunk at the level of the tuberosities of the fifth

or sixth cervical transverse processes is an effective means of blocking the sympathetic impulses to the head. This can be done by the anterior or anterolateral approaches as described. The latter has been found to be more generally satisfactory.

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# ON THE USE OF N. MUSCULOCUTANEOUS FOR NEUROTIZATION OF N. *RADIALIS* IN CASES OF VERY LARGE DEFECTS OF THE LATTER°

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WHILE STUDYING THE OPERATIVE TECHNIC which could be used in cases of large defects of the *n. radialis*, we first devoted our attention to the development of a practical method of transposition of the ends of the nerve on the anterior surface of the arm beneath the *m. biceps*. This method of transposition enabled us to repair defects up to 6 cm. (Lurje, 1947).

In the course of such operations we had to place ends of *n. radialis* in the interstitial space between *m. biceps* and *m. brachialis* and in this operative field the musculocutaneous nerve was always seen below the point where it supplies *m. coracobrachialis* and gives off branches to *m. biceps*. In the middle of the arm the nerve gives off its more or less constant large upper branch to *m. brachialis*. We often observed that in the lower half of the arm, *n. musculocutaneus* gave off also 1 - 2 branches to *m. brachialis* and 1 or 2 small branches to *m. biceps* (the latter less constantly). In the elbow bend, laterally from the bicipital tendon, musculocutaneous nerve occasionally gave off the lower thin branch to *m. brachialis* and then became *n. cutaneus antibrachii lateralis* of the forearm. Because of considerable difficulty in stretching the ends of the *n. radialis* which have been transposed onto the anterior aspect of the arm, and being in doubt whether the central end of the nerve would be able to neurotize its peripheral end due to considerable tension, we have twice decided, in addition, to implant brachial branches of *n. musculocutaneus* into the peripheral end of the *n. radialis*. No technical difficulties were encountered in performing the implantation. Sections of *n. musculocutaneus* immediately below the origin of the main branches to *m. biceps* and above the lower branches to *m. brachialis*, does not affect considerably the active flexion in the elbow. This nerve can therefore be used as a neurotizer (nerve donor) in the lower half of the arm without further essential impairment to motor function. *M. biceps*, with its nerve supply intact, compensates entirely the lost function of the denervated part of *m. brachialis*. This consideration led us to believe that *n. musculocutaneus*, after being sectioned in the indicated place, can be used for neurotization of *n. radialis* by end-to-end suture, in cases of very large defects of the latter nerve which are located in the upper two-thirds of the arm and higher up in the axilla, when the method of transposition of the ends of *n. radialis* onto the anterior aspect of the arm cannot be used in dealing with diastasis. It is essential for the above operation that the upper end of the peripheral section of *n. radialis* be located not less than 6-7 cm.

* Submitted for publication, October 6, 1947.

above the external condyle of the humerus. Under such circumstances implantation end-to-end of *n. musculocutaneus* into the peripheral section of *n. radialis* can be accomplished without any tension if the *n. radialis* is first brought out between the fibres of *m. brachialis* into the interstitial space between the latter and *m. biceps*.

Anatomic studies carried out in the department of topographic anatomy (Director: Prof. Richter) showed that the branches of *n. musculocutaneus* in the space between *m. biceps* and *m. brachialis* in the lower half of the arm arise at varying levels. One large branch is given off to *m. brachialis* fairly constantly at the level of the middle of the arm or a little higher. This substantial branch can be isolated, if necessary sectioned as low as possible, and used as such for implantation into the peripheral end of *n. radialis,* especially when *n. musculocutaneus* in its lower section gives off only a few motor fibres to *m. biceps* and *m. brachialis*.

During the operation it is therefore desirable to examine *n. musculocutaneus* as far upwards as the borderline between the upper and middle third of the arm, in order to obtain a clear picture of the type of its branching and to determine what motor elements can be used for neurotization of *n. radialis*. This examination should be accomplished without excessive skeletization of the nerve or destruction of its relations with the adjacent tissues and with full preservation of its blood supply. Since large defects of *n. radialis* usually occur in the middle third of the arm where the nerve lies close to the bone, the peripheral end of the nerve in most cases is long enough for a successful operation. It should be pointed out that in cases of large defects of *n. radialis,* operative technic requires the use of two incisions in order to make possible the isolation of both ends of the nerve. The first incision, described by Richter, is made in the upper third of the arm on its internal surface—for isolation of the central end of the nerve and estimation of the extent of the defect. The second incision is made along the brachioradial groove on the external surface of the arm in its middle and lower third. Having established that the defect of *n. radialis* is very large, from the external incision we separate the biceps from the brachialis and isolate the trunk and branches of *n. musculocutaneus,* divide it in accordance with the indications and conditions as outlined above. Neurotization of the freshened peripheral end of *n. radialis* after it has been first exposed in the brachialradial intermuscular groove is then performed. Atrophy of the peripheral end of the *n. radialis* diminishes somewhat a disproportion between the cross-sections of the nerve-recipient and nerve-donor. A large number of sensory fibres in the latter should not influence considerably its capacity to neurotize the nerve-recipient with motor elements. In the process of regeneration nerve fibres give growth to a large number of collaterals. Experimental data of Kilvington, Kennedy, Feiss, Aird and Naffziger show that thinner nerves being sutured with their central ends into the peripheral ends of the thicker

nerves are capable of giving good neurotization of the latter with full restoration of their motor function.

Implantation of the musculotaneous nerve into *n. radialis* has been performed by us in four cases. Two cases suffered shot wounds; these patients came for treatment after having been operated unsuccessfully in other institutions. In one case there was a subcutaneous rupture of *n. radialis,* and the other patient had a rupture of the nerve with open fracture of humerus.

Two cases are particularly interesting.

**Case No. 1.** (demonstrated at the conference of the Neurosurgical Institute A. M. N., March 8, 1947). Patient S., 20 years old. Entered the Institute October 25, 1945. Was wounded March 22, 1944, in the left arm with open fracture of the humerus. A "wrist-drop" developed immediately after the injury, extension in the radiocarpal and meta-carpophalangeal joints was lost. Soon afterward causalgia also appeared with predominant



FIG. 1.　　　　　FIG. 2.

FIG. 1 and 2. Demonstrating appearance of extension in radiocarpal joint eight months following removal of third thoracic sympathetic ganglion on left side.

localization in the zone of innervation of *n. ulnaris*, while the motor function of the latter remained unaffected. During 1944 three operations were performed on the arm; a fourth operation was a denudation and alcholization of *n. ulnaris* in the forearm, and a fifth operation was a neurotomy and neurexairesis of *n. ulnaris* at the level of the radiocarpal joint. In spite of all the above operations, causalgia persisted and the clinical picture became complicated with a paralysis of the distal branches of *n. ulnaris.*

Operation (Lurje) Nov. 4, 1945. First incision—18 cm. long—was made on the external surface of the arm with continuation onto the brachio-radial furrow. *M. biceps* and *m. brachialis* were drawn aside from *m. triceps.* In the lower part of the incision only the peripheral end of *n. radialis* was found. Another incision—20 cm. long—was made on the inner side of the arm from *m. pectoralis major* to the lower third of the arm. In the upper part of the wound the central neuroma of *n. radialis* was found. The defect of the nerve was so large that it could not be repaired by the method of transposition of

its two ends onto the anterior surface of the arm. *N. musculocutaneus* was exposed, its junction was tested electrophysiologically, and then it was divided distal to the origin of its principal branches to *m. biceps*, but proximal to the origin of several rather conspicuous branches to *m. brachialis*. The central end of the *n. musculocutaneus* was implanted into the freshened peripheral end of *n. radialis*. In addition a denudation of the brachial artery was performed extending through the whole medial incision. Both incisions were closed in layers.

In spite of denudation of the brachial artery the causalgic pains re-appeared three days after the operation. July 1, 1946 the patient was admitted into the Yauza Hospital Medsantrud with persistent causalgic pains. Examination revealed that *m. brachio radialis* had begun to contract. On July 12, 1946 the third thoracic sympathetic ganglion was removed on the left side (Lurje); and thereafter causalgic pains disappeared entirely. In February, 1947 extension in the radiocarpal joint began to appear and was quite good when the patient was examined on March 7, 1947 (see Figs. 1 and 2). Extension in the metacarpo-phalangeal joints was not restored. Paralysis of the distal branches of *n. ulnaris* persists.

**Case No. 2.** Patient L., 22 years old, was wounded March 28, 1944 with injury of humerus and *n. radialis* on the left side. Had undergone three previous operations for osteomyolitis of the humerus, at one of the hospitals in Moscow. Another operation was performed for paralysis of *n. radialis*, whereby a large defect was found and this was replaced with section taken from the peripheral end of the nerve dissected longintudinally. The patient was admitted into the Medsantrud Hospital April 9, 1946 with a picture of paralysis *n. radialis* without any apparent symptoms of regeneration. Operation April 17, 1946 (Lurje). *N. radialis* was exposed from two incisions, one on the inner and the other on the outer side of the arm. There were large scars and complete cicatricial degeneration of the transplanted nerve tissue; there was a neuroma on the central stump of the injured nerve. After the ends had been freshened, the defect was so large that direct neuropathy with transposition of the nerve ends onto the anterior surface of the arm was impossible. *N. musculocutaneus* was sectioned above the origin of two branches to *m. brachialis* and its central end implanted end-to-end into the peripheral end of *n. radialis*.

Examination on May 5, 1947 revealed presence of active contractions of *m. brachio-radialis* and appearance of slight extension in the radiocarpal joint.

These two cases demonstrate that neurotization of *n. radialis* by implantation into it of *n. musculocutaneus* can be performed with clinical success in cases of large defects of the former if a sufficient length of the peripheral end of *n. radialis* remains available in the arm, and this can be achieved without seriously impairing the principal function of the musculocutaneous nerve, namely, flexion of the elbow.

We believe that neurotization of *n. radialis* with *n. musculocutaneus* becomes particularly important when large defects in the former are accompanied by injury of the median and ulnar nerves. In such a case, the plastic operation on tendons, according to Pertes and Tichonovich, as it is done in cases of isolated injury to *n. radialis,* cannot be performed successfully. Chaklin regards good function of the median and ulnar nerves, as well as of all muscles innervated by these nerves and of all joints of the wrist and fingers, as the criterion for success of plastic operation on tendons. Therefore, in patients such as our Case No. 1, where there was paralysis of both *n. radialis* and of *n. ulnaris,* our operation was especially indicated as it is capable of restoring active extension of the wrist.

In the course of usual healing of the nerve wound with secondary neuror-rhapy, the nerve fibres regenerate twice: the first regeneration leads to formation of the neuroma and only repeated regeneration, which follows suturing the freshened ends, results in neurotization of the peripheral segment.

In the operation of implantation of *n. musculocutaneus* into *n. radialis*—as in the other similar heterotopic operations—fresh neurotizing fibres were introduced into the peripheral section of the injured nerve. The good regenerative potency of these fibres is immediately realized in the biologically fully prepared bed of the peripheral end of the nerve. When the defect of *n. radialis* is situated high up, the implantation described here, being performed below the zone of trauma and scarification, will be undertaken under the "ideal" conditions for regeneration, since the zone of the nerve suture will be surrounded by healthy and not scarified tissues. It is well known that the regenerative capacity of the axons of the central end and of their cells diminishes if a considerable time elapses after the trauma (Foerster, Egorov, Chubumaher, Bondarchuk), and particularly so with repeated operative interventions. Therefore, neurotization of the injured nerves with freshly cut nerves should be attempted only when local anatomical conditions permit. Both our patients were operated relatively late (19 and 25 months) after trauma and the regeneration obtained should diminish our pessimism regarding late restorative operations on the nerves.

Sometimes conditions arise which indicate a high implantation of *n. musculocutaneus* into *n. radialis*. This can be performed when large and irreparable defects are present in these nerves in the pectoral region if the central section of the musculocutaneous nerve is sufficiently long. The latter can then be implanted into the peripheral section of *n. radialis* if it is technically possible. The patient would, of course, lose flexion of the elbow, if the median nerve does not give accessory branches to *m. biceps* and *m. brachialis* lower in the arm. In performing such implantation we first split the peripheral end of *n. radialis* and separate from its main principal trunk the branches to *m. triceps* and also cutaneous rami to the dorsum of the arm and forearm, which all lie together with the main trunk within the common epineurial sheath. The central end of the musculocutaneous nerve is then implanted into the trunk of *n. radialis*. In the presence of paralysis of *n. musculocutaneus* neurotization of the branches to the triceps is not important as the patient will have to use an apparatus fixing the forearm at a 90° angle to the arm. Furthermore, separation of the above branches makes the cross-sections of the nerve-donor and nerve-recipient more comparable. Such an operation has been performed in the Medsantrud Hospital April 19, 1947 (Prof. Lampert and Lurje) on a 55 year old patient D. After removal of a tumor (neuroma type) large defects resulted in the musculocutaneous nerve and in *n. radialis,* which were imbedded in the tumor, while the central end of the former nerve was sufficiently long to permit its implantation into the peripheral end of *n. radialis.*

## CONCLUSIONS

1) In cases of very large defects of *n. radialis*, which are located in the upper two-thirds of the arm and in the axillary region, *n. musculocutaneus* can be employed for neurotization of the injured nerve.

2) *N. musculocutaneus* should be sectioned below the origin of the principal branches to *m. biceps* and above the origin of the branches to *m. brachialis* and then its central section implanted end-to-end into the peripheral section of *n. radialis*.

A definite regeneration of *n. radialis* has been obtained in two cases after implantation into this nerve of *n. musculocutaneus*.

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# THE USE OF MECHANICALLY WOUND BOBBINS FOR HANDLING AND DISPENSING NON-ABSORBABLE SUTURE MATERIAL, WITH OBSERVATIONS ON THE TENSILE STRENGTH AND STERILITY OF MECHANICALLY WOUND SUTURE MATERIAL [*]

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IT IS THE GENERAL SURGICAL PRACTICE to prepare non-absorbable suture material for sterilization by hand, winding small lots on rubber tubing, glass rods, cardboard, rubber-edged wooden boards, or as loose skeins. At the operating table it is the nurse's duty to prepare from these lots single strands of suitable length for sutures and ligatures. Some surgeons, when tying a series of ligatures, reel off the required lengths from a previously wound tube or rod held in the hand.

The cumbersome and time-consuming nature of these technics has prompted the trial of metal bobbins, bobbin cases, and a motor driven bobbin winder. It was felt that long lengths of non-absorbable suture material could be quickly wound on metal bobbins using a motor driven winder, both bobbins and winder being of the types ordinarily used on domestic sewing machines. These winders and bobbins were secured from local sewing machine dealers.

A fractional horse-power motor was equipped with a rubber stopper on the shaft to serve as a friction drive for the bobbin winder, (Fig. 1) and the bobbin winder was arranged so that it could be engaged or disengaged from the driving wheel at will. A spindle to hold the spool of suture material and a guide for the suture material were added. The only tension on the suture material while being wound on these bobbins was the friction of the spool on the spindle and the suture material passing through the guides. In one assembly, grinding and polishing wheels were incorporated for use in sharpening and polishing hollow or surgeons' needles (Fig. 2).

The metal bobbins used are 33 mm. long with 9 mm. flanges on the ends, (Fig. 3-C) and were also purchased from sewing machine dealers. They are probably made of brass plated steel.

The cases to hold the bobbins served as suture dispensers, and two types have been used to date. One type, (Fig. 3-A) of stainless metal was made for us by the American Hospital Supply Corporation through the kindness of Mr. E. H. Blount of their Atlanta office. It is 6.0 cm. long and 1.5 cm. in outside diameter and allows sufficient room within it for the bobbin to rotate and also move longitudinally as suture material is being dispensed through the slot cut in one side. Holes are drilled in each end to facilitate sterilization.

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The other type of case and suture dispenser (Fig. 3-B) is made of black phenol formaldehyde molding material and were secured from the Wheeling Stamping Company in Wheeling, W. Va. These are 6.5 cm. long and 1.5 cm. outside diameter and, after purchase, a slot was cut in one side and a hole

FIG. 1.
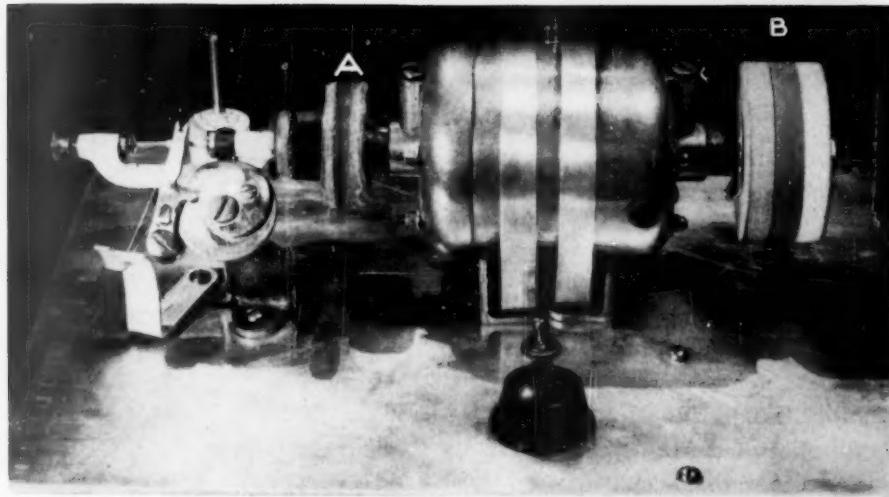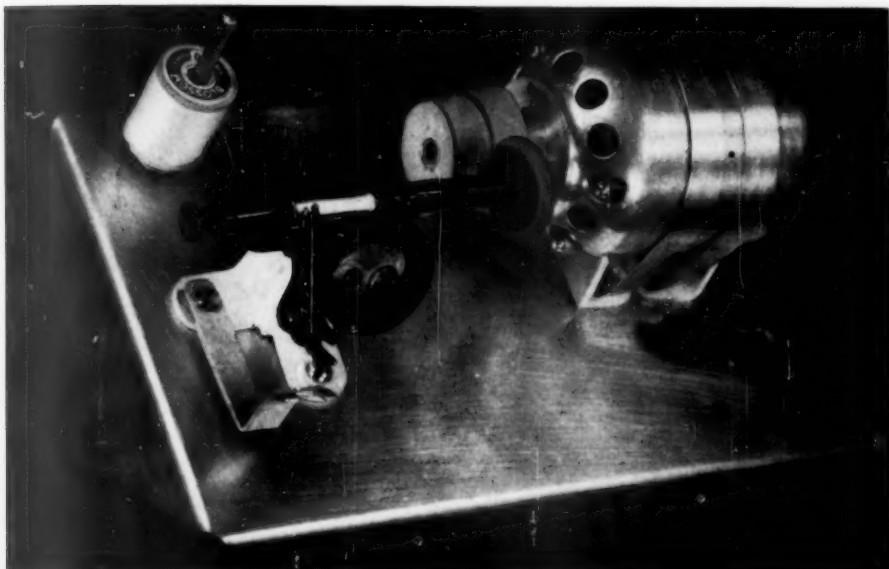


FIG. 2.

FIG. 1.—One type of motor driven bobbin winder. FIG. 2.—A type of motor driven bobbin winder incorporating a wheel (A) for polishing surgeon's or hollow needles, and a grinding wheel (B) for sharpening needles.

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drilled in each end. These cases have not been harmed by countless trips through the autoclave.

In considering the clinical use of this equipment, attention had to be given to two important factors :—

1. Alterations in tensile strength
2. Sterility of non-absorbable suture material after it was wound mechanically on these metal bobbins and either boiled or autoclaved.

Experiments were then carried out to study these two factors.
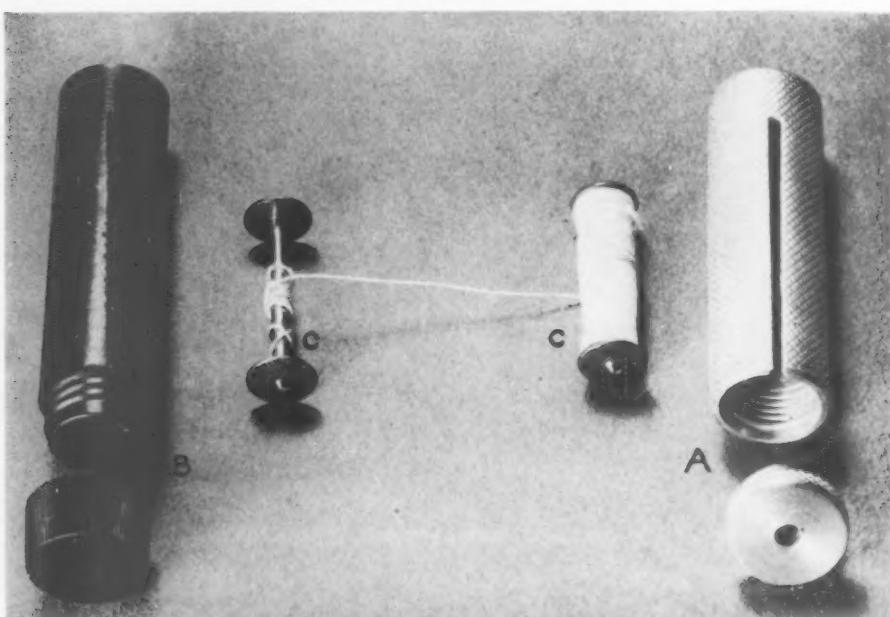


Fig. 3.—Types of bobbins and bobbin cases used. The stainless steel case is shown at (A) the case of phenol formaldehyde molding material at (B). The bobbins used are shown at (C).

## STUDIES ON TENSILE STRENGTH OF NON-ABSORBABLE SUTURE MATERIAL AFTER WINDING AND STERILIZING ON MECHANICALLY WOUND BOBBINS

Meade, Ochsner, Dixon and Long[1, 2, 3, 4] have given repeated warnings that the tensile strength of cotton will be appreciably impaired if the materials are boiled or autoclaved under any tension, as when wound on wood, glass, metal or even rubber tubing, which does not allow enough slack for normal shrinkage. Localio, Casale, and Hinton,[7, 8] who stated that cotton loses strength during sterilization, were criticized by Thorek[6] because they based their conclusions on samples sterilized on mechanically wound bobbins.

Mr. Frank R. Redman,[5] a well known consultant to the textile industry, feels that from his own experience boiling and autoclaving temperatures do not harm cotton fibres and have no effect on the strength of cotton thread if the thread is not held under tension while at the elevated temperature. He ex-

plained that during the original spinning of the yarn there is some tension which elongates the yarn by deforming the fibres. When this new thread is heated under tension the fibres become soft, thereby losing their grip and making the thread weaker. If, however, there is minimal or no tension during heating, the fibres return to their original shape and become interlocked to a greater extent than before heating. He suggested that if the thread is wound very loosely on the bobbins, there would be enough slack to allow the fibres to return, i.e., shrink, to their natural state, and the strength of the thread would not be impaired and might even be increased.

In view of these reports, experimental studies were carried out on several types of suture material to determine how much, if any, was the difference in tensile strength between non-sterile control samples, control samples sterilized after winding loosely on gauze, and test samples sterilized after winding on bobbins.

For the cotton materials, this study was also, in effect, a rough quantitative test determining whether the tension of the bobbin-wound materials was enough to prevent normal shrinkage and thereby to weaken the thread.

### MATERIALS AND METHODS

The materials tested were: No. 40 J and P Coats six cord plain cotton, No. 60 J and P Coats six cord plain cotton, No. 60 Blossom mercerized cotton, No. A Belding-Corticelli black twisted silk, and No. 4-0 serum proof braided silk (Deknatel), all purchased on the open market.

From each sample, testing was carried out on ten or more consecutive strands of 30 to 40 cm. in length. The upper end of each strand was wound around a cylindrical bar and the lower end around a horizontal spool holding a basket for weights. In this way the free strand was between 10 and 20 cm. in length and was attached at each end to a smooth surface with no acute angles. A basic initial weight pull of well below the breaking strength was determined for each sample before recordings were made. Each test was started by gently attaching the basic weight to the lower end of each strand and allowing it to hang freely, but not untwisting for 15 seconds. Then increments of 20 Gm. were added every five seconds until the strand broke.

Control readings were taken on samples directly from each spool. Samples of each material were then wound on gauze and on a bobbin before sterilizing. Separate samples of each were sterilized respectively by boiling 20 minutes, 30 minutes, one hour and two hours, and by autoclaving one, two, and three times at the usual temperature of 250°F. (15 pounds pressure) for a minimum of 15 minutes each. Those autoclaved more than once were allowed to cool and dry before re-autoclaving, and all samples were tested dry.

Since the knot is the weakest part of any suture, as shown by Taylor,[9, 10] readings were also taken on knotted strands of each sample. Each strand was cut in half and then tied with a single square knot snugly by hand before the weights were added. Invariably the strand broke at the knot. Occasionally the

TABLE I.—Mean tensile strength and standard deviations in grams of suture materials sterilized on gauze and on bobbins. N = number of observations, which is 10 unless otherwise noted. $t$ = value of $t$ in Student's $t$-test for unique samples. SI = Significant difference at 1% level (For $N_1 + N_2 - 2 = 18$, $t = 2.878$) S5 = Significant difference at 5% level, but not at 1% level. NS = Not significant at 5% level (For $N_1 + N_2 - 2 = 18$, $t < 2.101$). * = See comments in text.

twisted black silk knots slipped out with the basic weight, and these strands were discarded.

### RESULTS

The mean breaking strengths with their respective standard deviations to the nearest whole number are recorded in Table I. These results are tabulated for each sterilizing treatment in pairs representing the gauze-wound control sample and the bobbin-wound test sample. The difference between the means and also the $t$ value* for the significance of this difference is recorded beneath each pair, with letters denoting whether this difference is of no significance at the 5% level (NS), of significance at the 5% level (S5), or of significance at the 1% as well as the 5% levels (S1). The differences are noted as positive $(+)$ if the bobbin-wound mean was larger than the gauze-wound control mean. and as negative $(-)$ if the bobbin mean was smaller than the control mean.
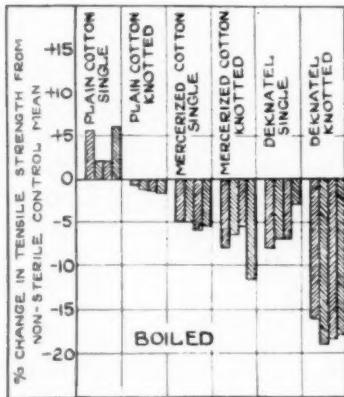
CHART I-A                              CHART I-B
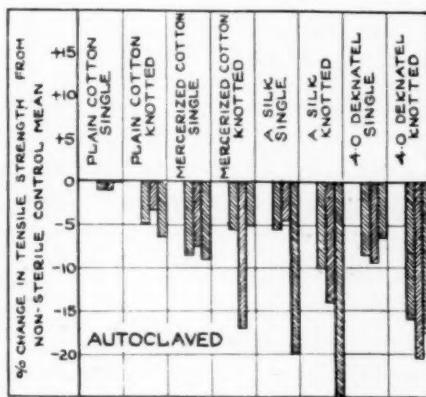


CHART I-A.—Average changes in tensile strength due to boiling. Computed from Table I. Reading from left to right in each group of cross-hatched columns, the columns indicate respectively the per-cent changes in tensile strength after boiling for 20 minutes, 30 minutes, one hour and two hours. I-B.—Average changes in tensile strength due to autoclaving. Computed from Table I. Reading from left to right in each group of cross-hatched columns, the columns indicate respectively the per-cent change in tensile strength after autoclaving once, twice and three times.

For reasons to be discussed later the significantly different pairs have been classified into two groups, those significant at the 5% level and those significant at the 1% level as well as at the 5% level. The "5% level" of significance denotes that the odds are at least 95:5 (19:1) that the difference between the means did not occur by chance. The "1% level" denotes that the odds are at least 99:1 against chance.

Of the differences between means in the 63 pairs reported, 48 (or 76%)

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*The $t$ value is a ratio of the difference between the means to the standard error of this difference, with suitable corrections being made for the small number of strands tested in each sample.[11]

were not significant and 15 were significant at the 5% level. Of these 15 pairs with significant differences ten of the bobbin-wound samples were stronger and five were weaker than their respective gauze-wound controls. Only eight of the 63 pairs showed significant differences at the 1% level, and of these, five of the bobbin-wound samples were stronger and three were weaker than their controls.

With the knotted strands, in only three of 31 pairs were there significant differences between the means, the bobbin-wound samples being stronger than their controls. In all 63 pairs, and disregarding significances, the bobbin-wound materials were stronger in 36 and weaker in 27 than their respective gauze-wound control materials.

The standard deviations for single strand non-sterile controls ranged from 25 Gm. for twisted silk to 60 Gm. for No. 40 plain cotton. For single strands sterilized on gauze the standard deviations ranged from 13 Gm. for twisted silk to 82 Gm. for No. 40 plain cotton. For those sterilized on bobbins, the range was essentially the same, i.e., from 13 Gm. for twisted silk to 86 Gm. for No. 40 plain cotton.

With the knotted strands the standard deviations were generally higher and covered a larger range. For the non-sterile controls they ranged from 36 Gm. for the twisted silk to 65 Gm. for No. 60 plain cotton. For those sterilized on gauze, deviations ranged from 31 Gm. for No. 40 plain cotton to 121 Gm. for the same material. For those sterilized on bobbins, deviations ranged from 27 Gm. for No. 40 plain cotton to 103 Gm. for No. 60 mercerized cotton.

The observed data incidentally shows the effects of knotting and of repeated sterilizations on tensile strength with exclusion of the factor of bobbin winding.

A comparison of the mean strengths of samples tested single and knotted but otherwise treated the same way showed consistent and significant weakening of the knotted strands. The percentages of loss of tensile strength are summarized in Table II. The smallest percentage loss was with No. 60 mercerized cotton, the average being 21% with a range of 9 to 32%. The greatest loss was with No. 60 plain cotton, the average being 28% with a range of 16 to 40%. The over all average in 60 comparisons was 25% with a range of 9 to 40%.

Comparisons of the mean tensile strengths of sterilized materials with the strengths of their respective non-sterile controls were analyzed for significant differences. For the sake of brevity, only a few representative figures are recorded in Table I adjacent to the spool control values. Number 40 plain cotton tested single showed a consistently significant increase after sterilization, but the same material knotted and the mercerized cotton showed decreases in strength. The No. 60 plain cotton varied above and below the control value, but was equal to or less than the control in all autoclaved samples. Black twisted silk lost strength rapidly with repeated autoclaving. The serum-proof

braided silk lost strength with the initial sterilization but subsequently showed no appreciable changes.

Chart I is a composite summary of per cent changes due to sterilization. Boiled plain cotton showed a tendency to increase in strength. Mercerized cotton and both types of silk showed decreases mentioned above. All knotted sterilized samples showed decreases from the knotted non-sterile controls. This was especially so with both types of silk.

### SUPPLEMENTARY STUDIES AND RESULTS

It will be noted that the non-sterile control mean for No. 40 plain cotton was obtained from 40 strands. The first 20 of these strands showed a mean breaking strength of $1069 \pm 50$ Gm. The other 20 strands were taken from the last portion of the same spool and showed a mean strength of only $1027 \pm 62$ Gm. The difference between the means is 42 Gm., and $t$ equals 2.35, which denotes a significant difference at the 5% level but not at the 1% level. In this case the mean of all 40 strands $1048 \pm 60$, has been recorded in Table I.

The significantly different pair of No. 60 plain cotton autoclaved one time was repeated twice with new samples each time. The means for one pair were gauze $894 \pm 40$ Gm., bobbin $866 \pm 57$ Gm., and for the other, $964 \pm 54$ Gm., bobbin $930 \pm 59$ Gm. There is no significant difference within each pair, but a highly significant difference between each gauze-wound control.

The mean reading for 10 strands of serum-proof braided silk autoclaved two times on gauze was computed and has been recorded as $840 \pm 41$ Gm., being 90 Gm. less than the bobbin-wound mean. Additional readings were then made on the 7 remaining consecutive strands from the same gauze-wound skein. The mean proved to be $980 \pm 24$ Gm., which is significantly different at the 1% level from the first 10 strands and also from the bobbin-wound sample. However, the mean of all 17 strands was $898 \pm 80$ Gm., which is not significantly different from the bobbin mean of $930 \pm 27$ Gm. On the other hand, four additional unsterile and two additional boiled gauze-wound control tests made from a new spool of the same size and brand of serum-proof braided silk showed respectively no significant differences even at the 5% level.

### COMMENT

It is generally conceded that the 5% level of significance between differences is strict enough for critical analysis. We have pointed out that, of the differences in mean tensile strength of 63 comparable pairs of gauze-wound and bobbin-wound suture materials, only 15 were of significance at the 5% level, and that of these, the bobbin-wound materials were stronger in 10 and weaker in 5.

In view of the fact that the analysis of the non-sterile control figures of No. 40 plain cotton showed that cotton from the same spool could vary significantly at the 5% level, the more strict test of significance at the 1% level was also applied. With this test only 8 pairs showed a significant difference, and of these the bobbin-wound materials were stronger in 5 and weaker in 3.

In summary, then, 76% of the tests showed no significant differences at the 5% level, and 87% showed none at the 1% level. Of the cases where significant

differences were demonstrated, the bobbin-wound materials were stronger than the gauze-wound ones in a ratio of about 2:1, which is of no significance in the over all analysis, because in the 63 pairs the bobbin mean was stronger in 36 and weaker in 27, a ratio of only 4:3.

We conclude, therefore, that winding suture materials without tension on these bobbins prior to routine sterilization has no appreciable effect on the ultimate tensile strength of the sterilized materials. And, in the case of cotton, the tension with which it was wound on the bobbins was not enough to prevent normal shrinkage.

An explanation for the presence of the demonstrated significant differences is suggested by the supplementary studies. The repeated studies on the No. 60 plain cotton autoclaved one time showed a significant difference between the two gauze-wound samples. This suggests that the significant difference in the original study was due to the variability of the cotton within Lot A, just as the demonstrated difference between the non-sterile controls of Lots A and B was also significant.

In the repeated study of an entire 25 yd. spool of No. 4-0 serum-proof braided silk, we found no significant variation in tensile strength. This suggests that the samples used for the original study were picked by chance from a non-uniform lot of material.

In other words, we believe that the demonstrated significant differences between the means of consecutive strands receiving the same treatment in these experiments were probably due to lack of randomness in sampling rather than to the effect of winding on bobbins.

The average decrease in tensile strength of 25% due to knotting alone confirms the work of Taylor and others that knotted strands are weaker than straight single strands. Of course, the human factor in the tying of the knots may partially account for their observed larger standard deviations and differences between means.

As regards the effects of sterilization alone, our observations show a tendency for plain cotton to increase in strength if boiled, but to change little if autoclaved. This is in agreement with the theoretical prediction of Redman previously mentioned, and along with the decrease shown in silk the figures generally confirm the work of Ochsner, et al.[1, 2, 3, 4]

No attempt has been made to study all types and brands of non-absorbable suture material. These studies would indicate that for the materials used, the strength of the same size and brand may not only vary from spool to spool, but even vary significantly on the same spool.

All who have used cotton for sutures have the clinical impression that its tensile strength varies widely. From these studies, it appears that within the limits of routine practice, the variability in the cotton itself[8] and its high coefficient of friction[4, 10] are more likely causes of breakage at the operating table than are the time of sterilization and the tension under which the cotton was wound.

Repeated autoclaving or boiling of unused bobbin-wound cotton is not recommended. The possibility of actual weakening through rot or mildew would be present if either gauze-wound or bobbin wound material were contaminated and stored while wet. Furthermore, we have found that rust from the bobbin shaft often stains the inner portion of the thread if it is not used within a reasonable length of time after autoclaving. This latter objection might be overcome by storing sterile bobbin-wound materials in antiseptic solutions fortified with a reducing agent, such as sodium nitrite, or by using bobbins made of or plated with a non-corrosive metal.

STUDIES ON STERILITY OF NON-ABSORBABLE SUTURE MATERIAL AFTER WINDING AND STERILIZING ON MECHANICALLY WOUND BOBBINS

When wound with the motor-driven winder, each bobbin could hold ten to fifteen layers of suture material depending on the thickness of the samples used. Controlled studies were carried out to test the sterility of the material after winding bobbins full, placing them in the bobbin cases and subjecting them either to boiling for 30 minutes or autoclaving at 250°F., and 15 lbs. pressure for a minimum of 15 minutes each.

TABLE II.—*Percent Loss of Tensile Strength of Suture Materials Due to Knotting of Strands*

(Calculated from Comparable Mean Tensile Strengths Recorded in Table I)

| Material | Number of Comparison | Average | % Loss of Tensile Strength Range |
|---|---|---|---|
| No. 40 Cotton, plain | 15 | 27 | 18 - 35 |
| No. 60 Cotton, plain | 8 | 28 | 16 - 40 |
| No. 60 Cotton, Mercerized | 15 | 21 | 9 - 32 |
| No. A Silk, black twisted | 7 | 25 | 21 - 31 |
| No. 4-0 Silk, braided serum-proof | 15 | 27 | 19 - 32 |
| TOTAL | 60 | 25 | 9 - 40 |

TABLE III

| | Number Bobbins | Positive Cultures | Negative Cultures |
|---|---|---|---|
| Autoclaved | 20 | 0 | 20 |
| Boiled | 33 | 5 | 28 |
| Controls | 18 | 16 | 2 |

These experiments were carried out with the kind assistance of Dr. McDonald Fulton, Director of the Department of Bacteriology. He suggested that pure fresh cultures of *B. mycoides* be used since this organism is a spore-former and yet of relatively low pathogenicity when handled.

Each bobbin to be tested was wound with one layer of suture material and then contaminated with a fresh suspension of *B. mycoides* in normal saline. Then twelve to fifteen more layers of suture material were added to the bobbin and each bobbin placed in its case.

These were then divided into three groups—(A) This group was autoclaved as described above. (B) This group was placed in an incubator overnight. (C) This group was boiled for 30 minutes. Following these procedures,

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all but the 2 inner layers of suture material were removed from each bobbin and the bobbin was then cultured by dropping it directly into a test tube of infusion broth. All tubes were than incubated for four days. The results of these experiments are shown in Table III. All of the autoclaved materials were sterile, but 5 out of 33 of the boiled materials showed viable organisms still present.

These results lend evidence that autoclaving is a safe way to insure complete sterility of all the suture material on the bobbins, but that boiling should probably not be relied upon for asepsis.

### SUMMARY AND CONCLUSIONS

1. Sixty-three comparisons of the tensile strengths of various cottons and silks sterilized on gauze and on bobbins are presented. These comparisons have been made on knotted as well as single unknotted strands.

2. The tensile strengths of materials of the same brand and size may vary significantly not only from spool to spool, but on the same spool.

3. In 76% of our comparisons there were no significant differences at the 5% level between the tensile strengths of materials wound loosely on gauze and those wound mechanically on bobbins. In 87% there were no significant differences at the 1% level.

4. Considering the lack of randomness in sampling in these experiments we conclude that winding non-absorbable suture materials on our bobbins with minimal tension prior to routine sterilization has no appreciable effect on the ultimate tensile strength of the sterilized materials.

5. The knotting of a suture decreased its tensile strength on an average of 25%, the material adjacent to the knot being invariably the point of breakage.

6. Plain cotton tended to increase in strength if boiled, but to change insignificantly if autoclaved. Mercerized cotton and serum-proof braided silk tended to lose strength with initial sterilizations, but subsequently showed no appreciable changes with repeated autoclaving. Knotted sterilized strands were in all cases not only weaker than the knotted non-sterile controls but also tended to lose proportionately more strength than the single sterilized strands.

7. Full bobbins, containing approximately 15 layers of suture material should be sterilized by autoclaving rather than by boiling, for there is some question that the latter method effectively sterilizes the innermost layers of the suture material.

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# CARCINOID TUMORS OF THE RECTUM

## Report of Three Cases, Two with Metastases [*]

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### INTRODUCTION

EXCELLENT REVIEWS ON THE SUBJECT of carcinoid, or argentaffin, tumors of the gastro-intestinal tract are readily available.[1, 2, 3, 4, 5] These tumors were considered by early writers to be benign but because of their resemblance to carcinoma have been called carcinoid.[6] Further experience with the lesion, however, has shown that many of the tumors spread to regional nodes and some to more distant sites. It has been found that the incidence of metastases from carcinoid tumors of the small and large intestine is significant. These findings are in contrast to those of carcinoids of the appendix, the common site of the tumor, which show a low incidence of nodal involvement or more remote metastases.

Recently[7, 8, 9, 10] attention has been directed to primary carcinoid tumors of the rectum, previously considered to be a very rare lesion. Up to 1942 Stout[7] found record of only six cases[11-16] and in that year added six of his own. Since then the number has increased so that at present, at least 29 carcinoid tumors of the rectum are on record.[7-18] Only two of these have been associated with distant metastases.[13, 16]

We present three cases of carcinoid tumor of the rectum. All were diagnosed by surgical biopsy, and surgical exploration of the abdomen was performed in two cases. One of these patients (Case 1) showed multiple metastases at operation, died 18 months postoperatively and came to necropsy. The second patient, (Case 2) at operation, showed metastases to the paraaortic nodes, the right perinephric region, and the liver. She refused subsequent operation and treatment, and was living but markedly debilitated, losing weight, and bleeding by rectum six months postoperatively. The third patient (Case 3) had a small rectal polyp removed through a sigmoidoscope. Four months postoperatively he had no further symptoms and was being followed in the surgical out-patient clinic.

### CASE REPORTS

**Case 1** (**).—C.J.G., a 51-year-old white male entered the U. S. Naval Hospital, Philadelphia, Pa. on November 22, 1943 complaining of weakness and fatigue of two months' duration. Weight loss of about 15 pounds occurred during this period. Tarry stool and decreasing caliber of the bowel movements had been noticed for four months

prior to admission. The patient had had no bowel movements during the five days before admission. The history was otherwise not contributory and the positive physical findings were limited to the abdomen and rectum. There was mild right upper quadrant abdominal tenderness, the liver edge was felt at the level of the umbilicus, and the left lobe of the liver was said to be nodular. On rectal examination there was a moderately hard, movable, polypoid growth in the posterior wall of the rectum. A few flecks of blood were present on the examining finger. Laboratory examinations of blood and urine were essentially negative, as were roentgenograms of the chest and skeletal system. Barium enema and gastrointestinal series showed no abnormalities of the gastro-intestinal tract. Proctoscopic examination revealed three hard nodular masses on the left and posterior walls of the lower rectum. The nodules were covered by intact mucosa. A punch was inserted through the mucosa and tissue from the tumor obtained for histologic diagnosis. The pathologic report:
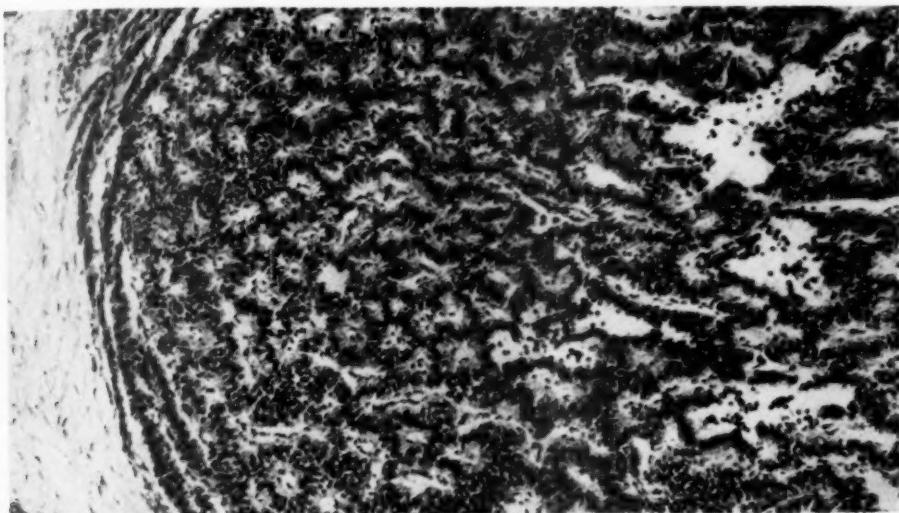


FIG. 1. Case 1.—Festoons of ribbons arrangement of columns of carcinoid tumor cells. Hematoxylin and eosin. (X200)*

*Gross description.* The specimens are two in number. They are firm, yellow, curled tissue masses, one of which is 5 x 3 x 2 mm. and the other 2 x 2 x 2 mm.

*Histologic description.* The sections consist of a rounded piece of rectal mucosa that for the most part is intact and essentially normal in appearance. Immediately beneath it, and extending throughout the narrow submucosal zone, are solid rounded masses of cells of an indeterminate type but having oval shaped nuclei of uniform size and quality with no hyperchromatic changes. Irregular infiltration of the mucosa has taken place as well as in areas in the deeper portions. The appearance is not that of primary carcinoma of the rectum.

*Diagnosis.* Carcinoid of the rectum. A repeat specimen was requested and at operation two firm tumors beneath the intact mucosa on the left side of the lower rectum were again found. They were movable and not connected. The lower was completely excised. Surgical pathologic report:

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* We are indebted to Mr. Leo Goodman, Boston City Hospital, for the photomicrographs appearing in this article.

*Gross description.* The specimen consists of a rounded grey-yellow mass 3 x 2.5 x 1.2 cm. It cuts with a slightly increased resistance and shows a homogeneous grey color throughout.

*Histologic description.* The sections consist of a large rounded mass of tissue covered on one side with intact and essentially normal appearing mucosa. The main substance is made up of compact islands and cords of cells that in places are arranged in a pseudo-acinar pattern. The cells all tend to be of cuboidal and columnar type and they are arranged in a longitudinal pattern without formation of lumens. The nuclei are of uniform size, shape and staining with no hyperchromatic tendencies. Mitotic figures are not seen. There is infiltration of the mucosal stroma and in places the tumor mass extends through the surface epithelium for a short distance. Infiltration of the underlying smooth muscle is noted in the deepest portions and isolated groups of cells are present between the muscle bundles. Silver stains reveal no definite granules in the cytoplasm of any of the tumor cells.
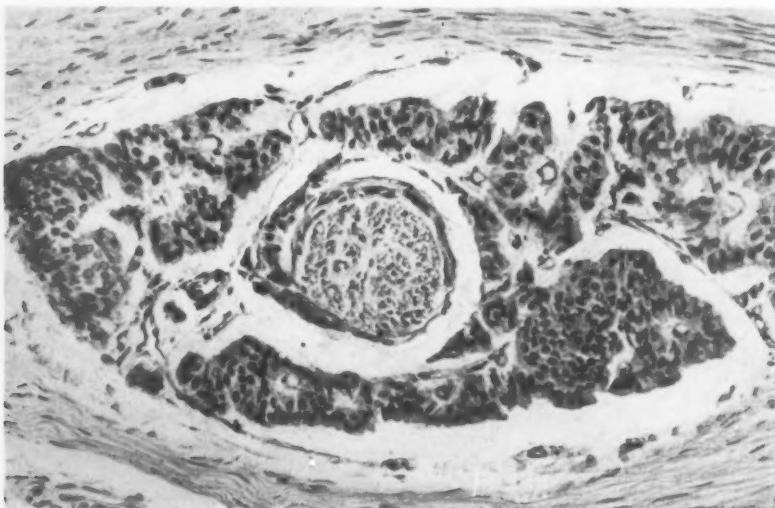


Fig. 2. Case 1.—Perineural lymphatic invasion by carcinoid tumor cells in rectovesical septum. Hematoxylin and eosin. (X400.)

*Pathologic diagnosis.* Carcinoid of the rectum.*

The patient was treated symptomatically and an abdominal exploration was performed. A small hard mass was palpated in the rectal wall, the liver was enlarged and nodular, and there was a small mass about the size of a marble attached to the lower pole of the right kidney. After a short convalescence, the patient was discharged on Feb. 16, 1944. He slowly lost weight and strength, and the liver and spleen became enlarged. Readmission to the same hospital on Dec. 29, 1944 revealed a red blood count of 2,320,000 per cu. mm. and a hemoglobin of 7 Gm. per 100 cc. The patient died on June 29, 1945 about two years after the onset of weakness and fatigue, symptoms which had been preceded by tarry stools for two months.

*Autopsy report.* (A-45-205, U. S. Naval Hospital, Philadelphia): Only significant findings are presented. The advanced emaciation of the face, thorax, and extremities

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* Both pathologic reports by courtesy of Captain H. M. Dixon (MC) USNR, at that time Chief of Laboratory, U. S. Naval Hospital, Philadelphia, Pa.

contrasted with a tremendously distended abdomen. The sclerae were icteric. The heart and lungs were essentially negative. The peritoneum contained 5,500 cc. of serosanguineous fluid. The liver was very large, weighing 13,200 Gm. The enlargement was generalized, although more prominent in the right lobe. The liver surface was made up of irregular, varying sized nodules from 1 to 20 cm. in diameter. The nodules were generally yellow-white but had hemorrhagic and cystic areas which contained bloody fluid. Section of the liver revealed that most of the organ was replaced by friable and cystic, nodular tumor. The spleen weighed 240 Gm. and was not remarkable. The gastrointestinal tract was completely negative except for the rectum. On the anterior rectal wall, 2 cm. above Hilton's line, there was a smooth somewhat firm area 1 cm. in diameter. The mucosa was apparently intact over the tumor, but between the latter and the bladder there was an irregularly outlined mass of white tissue directly connected to the submucosal tumor mass. Beyond and above this point in the rectovesical tissues, a little to the left of the midline, there were several oval and spherical masses, the largest measuring 1.4 cm. in diameter. These were firm and white or olive drab in color and one showed some
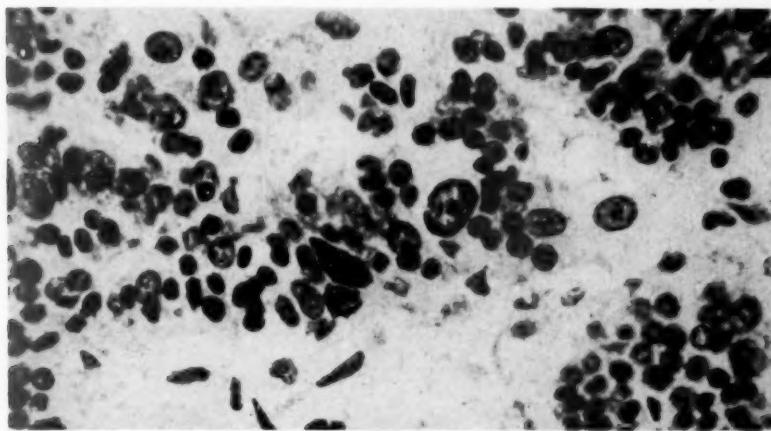


FIG. 3. Case 1.—Variation in size and shape of carcinoid cells in rectovesical tissues. Hematoxylin and eosin. (X1200.)

necrosis. The right kidney had two small nodules of white tissue with some hemorrhagic areas in each pole. The thyroid gland showed multiple small nodules up to 2 cm. in diameter, one of which was hemorrhagic. There were two large nodes adjacent to the head of the pancreas, and a third at the hilum of the liver. Section disclosed homogeneous pink firm tissue in all of these nodes.

*Microscopic description.* All tissues were fixed in formalin and stained with hematoxylin and eosin.

*Rectum and Rectovesical tissues.* There was a massive invasion of these tissues by cords and islands of tumor cells so that neoplastic tissue was predominant. The rectal mucosa was intact but raised by tumor. The typical tumor pattern present throughout these areas corresponded to that which Stout[7] has so aptly described as "festooning ribbons of columnar cells" (Fig. 1). The ribbons were composed of narrow strands of tumor cells, a few cells wide, whose long axes were perpendicular to the long axis of the ribbon. These cells contained round or oval nuclei of uniform size, each of which was about 2 to 3 times the diameter of a lymphocyte. The nuclei contained a diffuse chromatin stippling and no mitoses were seen. The cytoplasm of the cells was well demarcated only at the margins of the ribbons and intercellular boundaries could not be made out. A few cells showed small vacuoles in the cytoplasm. Some groups of cuboidal or columnar cells with

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small round nuclei were invading muscle planes. Occasionally a clump or medullary mass of polygonal cells, similar to those usually present in appendiceal carcinoids, were seen. Perineural lymphatic invasion was observed in some areas (Fig. 2). Blood vessel invasion was not seen. About one-half of the tumor, especially that near the serosal surfaces, differed somewhat from that previously described. Resemblance to the festooning ribbons was present but the ribbons were wider and less distinct, the pattern was somewhat labyrinthine, and the cytoplasm stained deeper with eosin. Some variation in size and shape of the nuclei occurred and occasionally nuclei four to five times the usual size were seen (Fig. 3). No prominent nucleoli were present and no mitotic figures were seen. A few tumor giant cells were observed. No definite gland formation was present, although the ribbons of cells gave a pseudo-alveolar configuration in some areas. No glandular secretions nor rosettes were seen. Silver stains had been performed on the first rectal biopsy and the report stated that there was some browning of the cytoplasmic granules of the tumor cells but neither these silver stains nor additional rectal tissue was available to us.
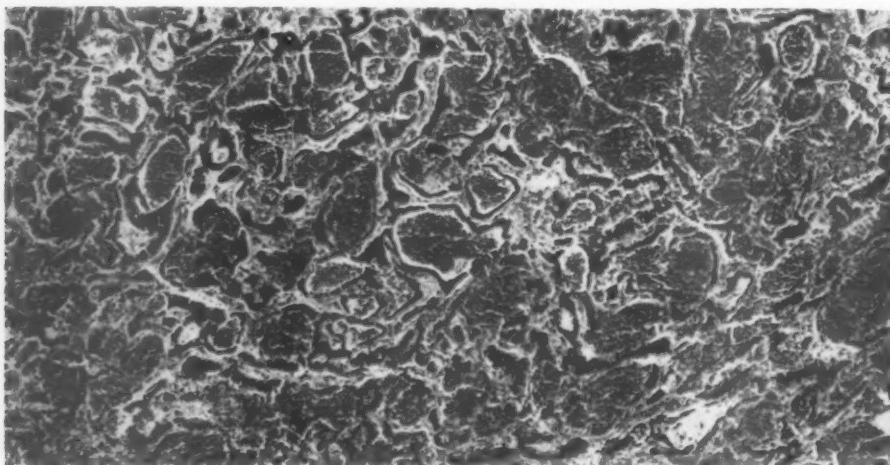


FIG. 4. Case 1.—Blood-filled cysts formed by metastatic carcinoid tumor in the liver. Hematoxylin and eosin. (X150.)

*Liver.* The liver tissue between tumor nodules was essentially normal except for some compression of liver cords. The histologic appearance of the tumor was strikingly different from that described above. Most of the tumor was composed of large blood-filled spaces of varying size (Fig. 4). The walls of these spaces were formed by one or several rows of cuboidal cells, although occasionally broad bands of cells separated the blood-filled spaces. The cells were generally cuboidal with indistinct cell boundaries although columnar cells were occasionally seen. The nuclei were oval to round and had a diffuse finely granular chromatin stippling. Between the cell borders of adjacent blood-filled cystic spaces there was usually a septum of connective tissue containing strands of collagen and small capillaries. The cystic pattern of the tumor was present in all the liver nodules examined, and in addition there were a few small focal collections of cells containing hyperchromatic atypical nuclei of varying size and shape and some tumor giant cells.

*Kidneys.* Tumor nodules were made up essentially of the characteristic festoons of ribbons of columnar cells although some blood-filled cystic areas, similar to those seen in the liver, were observed.

*Lymph nodes.* Tumor cells in the regional, mesenteric and peripancreatic lymph

nodes were composed for the most part of coils of ribbons similar to those seen in the rectum.

*Thyroid.* The tumor in the thyroid gland was composed of blood-filled cystic spaces lined with small cuboidal cells and similar to those seen in the liver.

*Final anatomic diagnoses.* Primary malignant carcinoid tumor of the rectum with invasion of the rectal wall, the rectovesical septum and perirectal nodes, metastases to the liver (massive), right kidney, thyroid, and to the peripancreatic and portal hilar nodes; ascites; emaciation; icterus.

**Case 2.** L.A., a 45-year-old white Italian housewife, entered the Boston City Hospital on Dec. 23, 1946 complaining of nausea, vomiting and marked constipation for one month prior to admission. This was the fourth similar episode within the previous year. No diarrhea or tarry stools were noted. Upon admission the only positive physical finding was tenderness in the epigastrium. Rectal examination at this time was considered to be negative except for some small external hemorrhoidal tabs. Laboratory examinations revealed normal blood and urine. A barium enema examination revealed no intrinsic gastro-intestinal abnormalities. At this time a somewhat enlarged liver was noted, and it displaced the hepatic flexure of the colon medially. The patient was discharged to the surgical outpatient clinic.

Readmission to the hospital three weeks later because of aggravation of previous complaints revealed upon digital rectal examination an annular mass, which just barely admitted the tip of the examining finger, 14 centimeters from the anal sphincter. A sigmoidoscope examination at this time showed an annular constricting lesion with the predominant mass on the posterior wall. The mass was hyperemic and bled easily upon touch, but there were no mucosal ulcerations. Two portions of the lesion were biopsied for histologic examination.

Following a report of the lesion as a carcinoid tumor of the rectum, abdominal exploration was performed. A firm fixed mass was palpable at the terminal rectum below the pelvic peritoneum. The liver and right para-aortic and pararenal areas were studded with large, firm, white tumor nodules. A terminal loop colostomy was performed and the patient's recovery was uneventful. Three weeks later she was discharged to her home. Social Service followup at her home six months later reported that she was having persistent nausea and vomiting and passing large amounts of blood per rectum. She was persuaded to reenter the hospital, but left a short time later, against advice, before any further examinations could be conducted. All subsequent attempts at further treatment were refused.

*Pathologic report*: (M.I.P.—S-47-284). The specimen was received in Zenker's solution and consisted of two small pieces of tissue, somewhat friable, with the larger measuring 1.5 x 0.4 cm.

*Histological descriptions.* Phloxine-methylene blue stain. In some areas the rectal mucosa was intact and normal. In others it was ulcerated and replaced by tumor cells. Throughout the entire rectal wall were masses, strands and columns of cells which had almost completely replaced the muscularis. There was a considerable amount of fibrous tissue accompanying the tumor cells, and foci of fibrin, polymorphonuclear leukocytes, lymphocytes and plasma cells were present throughout the rectal wall. The tumor cells did not show the characteristic festooning pattern of ribbons of cells but occurred in clumps, masses, or columns of round cells with fairly distinct cytoplasmic boundaries. In places the tumor cells had the appearance of a syncytial mass containing many nuclei and indistinct cell borders. The nuclei were round or oval and showed a diffuse chromatin stippling. There was a moderate variation in size and shape of the nuclei and some of them had prominent nucleoli. No mitoses were seen. The cytoplasm of the cells stained heavily with phloxine. No acinar arrangement was present. Connective tissue stains showed an abundant amount of fibrous tissue stroma. The tumor cells resembled those seen in the carcinoid tumors of the appendix but also showed some atypical features such

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as the variation in the size of the nuclei, and the presence of some prominent nucleoli. They lacked the festoons of ribbons arrangement seen in many rectal carcinoids. A modification of Bodian's protargol stain[19] revealed that granules in the cytoplasm of the Kultschitzky cells of the rectal glands stained black. Some connective tissue cells in the stroma between the glands also contained silver positive granules but in no cells, recognized definitely as tumor cells, could argentaffin granules be seen. Masson's technique for demonstration of argentaffin granules[2] was attempted on tissue fixed in Zenker's fluid and later "dezenkerized." No argentaffin granules were seen in the tumor cells although some were present in the cytoplasm of the Kultschitzky cells.

**Case 3.** P.J., a 69-year-old white male entered the Boston City Hospital on April 15, 1947 stating that he had had black stools for one week prior to admission. A similar episode had occurred six weeks previously. During the week prior to admission the patient experienced anorexia and weakness. Physical and laboratory examinations were
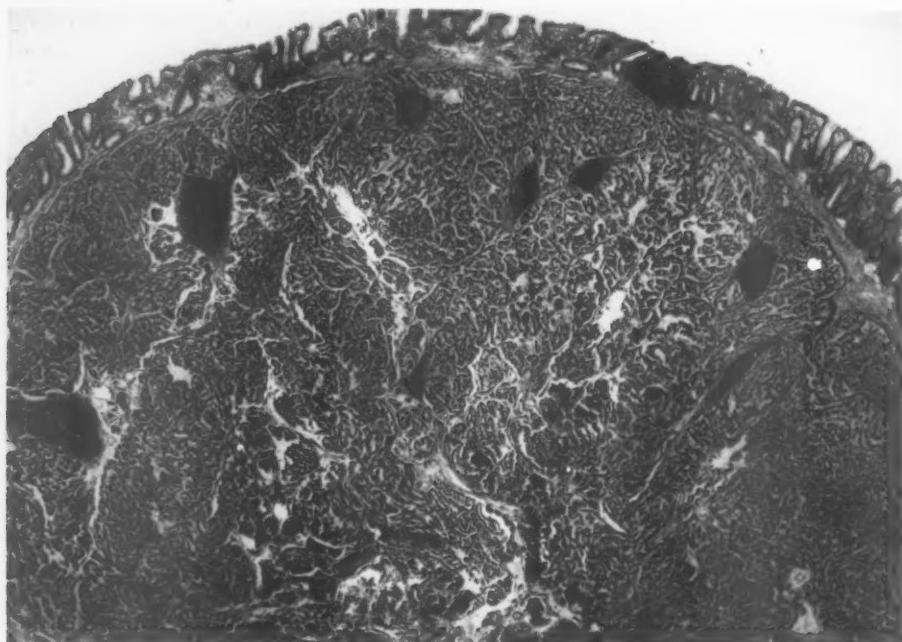


FIG. 5. Case 3.—Submucosal carcinoid tumor showing intact rectal mucosa. Phloxine-methylene blue. (X50.)

essentially negative. Sigmoidoscopy revealed a small polyp about 1.5 cm. wide and 2 cm. long with a small pedunculated base. It was located in the left and anterior walls of the upper portion of the rectum or at the recto-sigmoid junction. The polyp was removed for histologic analysis. A barium enema revealed diverticulosis but no evidence of other lesions.

*Pathologic report.* (M.I.P.—S-47-2445). The specimen consisted of five small fragments of tissue, received in Zenker's solution, the largest measuring 0.8 cm. in diameter.

*Histologic description.* Phloxine-methylene blue stain. The sections are those of a small rectal polyp covered with intact normal mucosa. Replacing almost the entire stalk of the polyp were typical festoons of ribbons of tumor cells (Fig. 5). The ribbons were narrow and averaged two to four nuclei in width. These nuclei were round or triangular in shape and contained a diffuse distribution of nuclear chromatin and no prominent

nucleoli nor mitotic figures. Occasionally nuclei two to three times the average size were seen. Cytoplasmic boundaries were distinct only at the margins of the ribbons. Also present in the sections were small foci of round, uniform-sized cells similar to those seen in the typical appendiceal carcinoid tumor (Fig. 6). Thin strands of fibrous connective
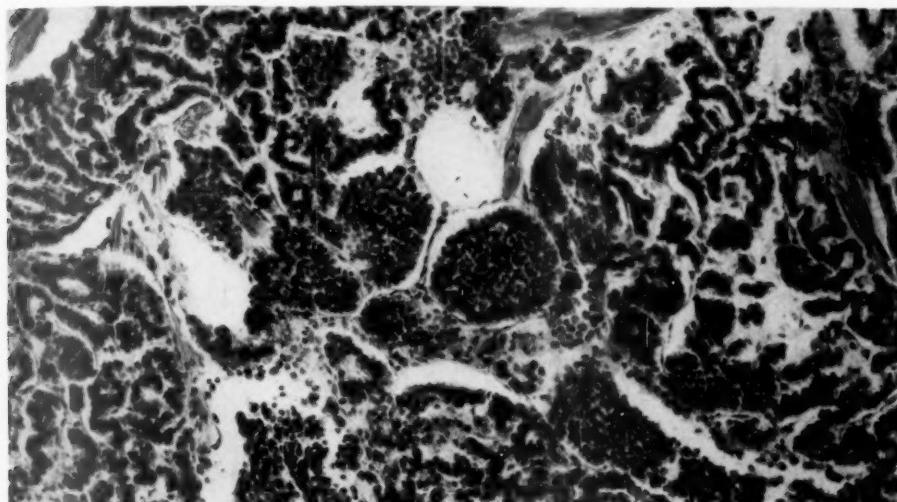


FIG. 6. Case 3.—Submucosal rectal nodule showing characteristic festoons of ribbons arrangement and also nests of carcinoid cells. Phloxine-methylene blue. (X300.)

tissue formed a loose supporting network for the polyp. Scattered throughout the tumor were foci of lymphocytes. No perineural lymphatic or blood vessel invasion was found. The specimen was considered inadequate as far as determining the extent of the invasion and further material was requested. To date this has been unobtainable. Bodian's protargol stain revealed black granules in the cytoplasm of the Kultschitzky cells of the rectal glands and in the cytoplasm of several cells in the interstitial tissue of the mucosa and in the stroma of the tumor. No granules could be seen in cells that were definitely identified as tumor cells. Masson's technic[2] on the tissue fixed in Zenker's fluid showed granules in the cytoplasm of the Kultschitzky cells but not in cells definitely identified as tumor cells.

### DISCUSSION

Since the studies of Oberndorfer[6] the term "carcinoid" had been used to designate these tumors of the intestinal tract that resemble carcinoma superficially and yet were believed to be benign because of their innocuous appearance histologically and their lack of distant metastases. The work of Masson culminated in his belief that these tumors were derived from the argentaffin (Kultschitzky) cells of the gastro-intestinal tract, and since then many authors have used his designation "argentaffin tumors".[2] We prefer the term carcinoid or carcinoid tumor because our tumors have not shown argentaffin properties. We admit the term is not ideal as the tumor's frequent malignant behavior belies its implied benignity. However, the difference in histologic appearance and clinical course warrant the use of the distinctive term "carcinoid" to separate it from the usual adenocarcinoma of the gastro-intestinal tract.

Carcinoid tumors of the gastro-intestinal tract occur about equally in both

sexes, and at all ages, but in general are most prevalent after the age of 40 years. The most common site of occurrence of these tumors is the appendix. Dockerty, et. al.,[20] state that 0.5 per cent of all appendices removed surgically show argentaffin or carcinoid tumors. Involvement of the ileum, the next most frequent primary site, is said by these authors to occur only a tenth as frequently as in the appendix. In general, the incidence of carcinoid tumors is low, and Ariel found[4] that in a series of 2,373 neoplasms of the entire gastro-intestinal tract, taken from both surgical and autopsy material, only 1.3 per cent were carcinoids.

The distribution throughout the gastro-intestinal tract of carcinoid tumors showing metastases varies somewhat from the overall distribution of both benign and malignant carcinoid tumors. In a series of 68 metastasizing carcinoid tumors of the gastro-intestinal tract collected from the literature by Miller and Herrmann,[21] the primary site of the tumor was the small bowel in 50 of the cases, the appendix in only 14, the colon in 3, and the stomach in one. The incidence of metastases has varied in large series. One author reported as low as 18 per cent,[3] whereas in a recent survey Ritchie and Stafford[5] found that of 332 cases of carcinoid tumor reported in the literature up to 1944, 126 (37.9 per cent) have shown metastases. Dockerty and Ashburn[22] state that carcinoids of the small intestine constitute 23 per cent of all malignant neoplasms in this region. Apparently, the few tumors found in the colon are associated with a high incidence of metastases as Wyatt[23] found that three of nine carcinoids of the colon showed metastases.

Rigdon and Fletcher reviewed the literature[8] on carcinoid tumors of the rectum up to 1946 and found 14 cases. We have found an additional reported case of a rectal carcinoid tumor.[17] More recently, Ehrlich and Hunter[9] have added ten more cases discovered in members of the Armed Forces of World War II. These occurred in males from 18 to 39 years of age and were reported in a series of 813 tumors of the gastro-intestinal tract. From the Mayo Clinic Jackman[10] reported four carcinoid tumors in a series of 87 consecutive patients with submucosal rectal nodules. Of this total of 29 carcinoid tumors of the rectum that have been reported in the literature, two have shown metastases. One of these, Koch's case,[13] showed invasion of the regional nodes, pelvis, bladder, ureters, and metastases to the liver. Siburg's case[16] showed local invasion of the rectal wall and metastases to the regional, sacral, and para-aortic nodes, the liver, and to the thoracic and lumbar vertebral marrow. Our case I showed invasion of the rectal wall, the rectovesical septum and adjacent nodes, and metastases to the liver (massive), right kidney, thyroid, and peripancreatic and periportal lymph nodes. Case II showed involvement of the nodes adjacent to the rectum and metastases to the liver, right pararenal area and para-aortic lymph nodes. Thus of a total of 32 cases four (12.5 per cent) have shown metastases.

The spread of the tumor is usually through the bowel wall to the regional nodes, thence to the liver and occasionally elsewhere. However, blood-borne

TABLE 1

| Case No. | Author | Year | Sex | Color | Age | Symptoms | Rectal Lesion | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 1 | Staltykow | 1912 | F | | 28 | None | Submucosal white nodule, 5 mm., diameter, 4 mm. thick, anterior wall, 5 cm. above anus. | |
| 2 | Reichel | 1924 | M | | 35 | None | Pea-sized nodule, 10 cm. above anus, normal mucosa. | |
| 3 | Siburg | 1929 | M | | 71 | Left rib pain, cyanosis, yellow sclerae, swelling of legs, abdomen, scrotum. | Pea-sized nodule, anterior wall, 4 cm. above anus. | Metastasis to regional, sacral, para-aortic node, liver, thoracic, lumbar, vertebral marrow. |
| 4 | Brunschwig | 1933 | M | | 63 | None | Submucosal nodule, loosely adherent, 0.5 cm. diameter, 8 cm. above mucocutaneous junction. | Found incidental to physical examination |
| 5 | Humphreys | 1934 | M | | 28 | | Polyp, 0.7 cm. diameter, 5 cm. above anus. | |
| 6 | Koch | 1940 | M | | 64 | Constipation, diarrhea—1 month, tenesmus. | Two-three cm. from anus an infiltrating lesion narrowing 10 cm. of rectum to lead pencil size. | Metastasis to regional nodes, pelvis, bladder, ureters, liver |
| 7 | Mallory | 1940 | | | | | | |
| 8 | Stout Case I | 1942 | F | C | 19 | Bleeding from rectum, constipation—1 year. | Round, polypoid mass, 18 x 17 x 15 mm., movable, intact mucosa, anterior wall, lower rectal segment, 5 cm. from anus, yellow-white. | Adenomatous polyp removed from adjacent area. Nine year survival, no recurrence |
| 9 | Case II | | F | C | 41 | Diarrhea, L.L.Q. pain—5 days, then constipation, anorexia, pain, weight loss—4 months. | Sessile tumor 7 x 4 mm., covered with mucosa, left anterior wall 5 cm. from mucocutaneous junction. | Ileocolostomy for regional ileitis 6 months later. Alive 2 years later |
| 10 | Case III | | F | C | 34 | Soreness, protrusion after stools —4 years. Recent rectal bleeding. | Firm sessile yellow-gray nodule, 11 x 8 mm., with some attached mucosa, anterior wall, 5 cm. above anus. | Hemorrhoids present |

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TABLE I (Continued)

| Case No. | Author | Year | Sex | Color | Age | Symptoms | Rectal Lesion | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 11 | Case IV | | F | W | 38 | Rectal bleeding—2 days. | Firm nodule, covered with mucosa, 7 x 6 x 4 mm., anterior rectal wall ampulla. | Hemorrhoids present. Patient alive, no recurrences 2½ years later |
| 12 | Case V | | F | W | 42 | None | Firm, oval plaque, 7 mm. in diameter, anterior rectal wall. | Incidental finding |
| 13 | Case VI | | M | C | 43 | None | Elevated, yellow, movable, flattened firm nodule in mucosa and submucosa just above anus. | Incidental finding. Leiomyosarcoma of stomach also present |
| 14 | Yaker | 1944 | M | | 29 | Difficulty in bowel movement, with obstructing sensation in rectum—few weeks. | Sessile, slightly raised, movable, red-brown nodule covered with mucosa, 1.3 x 1.2 x 1.0 mm., anterior wall, 4 inches above anus. | |
| 15 | Rigdon and Fletcher | 1946 | M | C | 60 | None | Innumerable, rubbery, movable, gray-white submucosal nodules from few mm. to 1.0cm. | Incidental finding |
| 16-25 | Ehrlich and Hunter | 1947 | M | | 18-38 | | | No malignant, nor metastatic lesions |
| 26-29 | Jackman | 1947 | | | | | Yellow surface (2 cases). | Locally invasive (2 cases) |
| 30- | Authors | 1948 | | | | | | |
| 32 | Case I | | M | W | 51 | Tarry stools, decreasing calibre — 4 months. Weakness, fatigue, weight loss — 2 months. | Three hard yellow nodules, intact mucosa, posterior and left lateral lower rectum, 5 x 3 x 2 mm., 2 x 2 x 2 mm. and 3 x 2 x 1.2 mm. Nodule, 1 cm., 2 cm. above Hilton's line. | Metastasis to regional and distant nodes, liver, thyroid, kidney |
| | Case II | | F | W | 45 | Nausea, vomiting, marked constipation — 4 episodes in prior year. Later, rectal bleeding. | Annular constricting mass, intact mucosa, prominent on posterior wall. Firm, fixed yellow-brown mass, 1.5 x 0.4 cm. at terminal rectum. | Metastasis to regional and distant nodes, liver, and kidney |
| | Case III | | M | W | 69 | Tarry stools — 6 weeks and 1 week prior to entry. | Polyp with pedunculated base, 2 cm. long, 1.5 cm. diameter, yellow-brown, left and anterior walls of upper rectum. | |

metastases have been reported in such organs as the spleen, dura, uterus, and ovary. We have seen a carcinoid tumor of the ileum which metastasized to the liver, spleen, pancreas, adrenals, ovary, heart and vertebral marrow. The metastases grossly usually resemble the primary tumor, being various combinations of yellow and white. The metastases in our Case I presented many cystic and hemorrhagic areas similar to the hemorrhagic liver metastases described by Ritchie and Stafford[5] and Gold and Grayzell.[24]

Of particular interest in carcinoid tumors of the rectum has been the lack of reduction of silver salts by these tumors. This reduction and the subsequent demonstration of black granules in the cytoplasm of tumor cells is characteristic of carcinoid tumors arising elsewhere in the gastro-intestinal tract. Stout noted that three otherwise typical carcinoids of the rectum did not reduce silver salts and one gave only a slight browning of the granules present. He postulated that the explanation for the lack of reduction was due to the absence of an enzyme, enteromin, which was necessary for the reaction. As previously mentioned, we were unable to demonstrate granules which reduced silver salts in the cytoplasm of the tumor cells in our cases.

Because of the wide distribution of argentaffin cells throughout the gastro-intestinal tract the multicentric origin of these tumors is possible. Dockerty, et al.,[20] stated that one-third of their cases showed multiple foci of tumor throughout the gastro-intestinal tract. Case I showed at autopsy that only the rectum was involved. The original proctoscopic examination showed three separate nodules in the rectal wall. Case II showed an annular constricting lesion in the rectum. Barium enema and exploratory operation demonstrated no other gastro-intestinal lesions. In Case III a barium enema was negative, but obviously the question of other foci cannot be decided at present.

### CLINICAL DATA

*Age and Sex.* The ages of the patients having a carcinoid tumor of the rectum have varied from 19 to 71 years and all intermediary decades have been represented. About one-half of the patients have been under 40 years. Metastatic lesions have occurred in patients 45, 51, 64, and 71 years. In 18 cases in which the sex of the patient was mentioned, 11 have been males and seven females. Metastatic lesions have occurred in three males and one female.

*Symptoms.* Of a total of 32 cases known to us (including our three cases) there has been no clinical data available in 13 cases. In nine other cases either no symptoms were mentioned or the tumors were findings incidental to physical examination or necropsy. The remaining 10 cases have had symptoms (Table I). Of these, four patients have had evidence of bleeding with tarry stools in two cases and frank bleeding per rectum in the other two. Constipation was associated with rectal bleeding in one of these cases and decreasing caliber of the stool with tarry stools in another. Three patients had either constipation or difficulty in bowel movement with an obstructing sensation in the rectum, but without bleeding. Three of the four patients with metastases showed the general symptoms of weakness, fatigue, weight

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loss and other symptoms usually associated with malignant neoplasms. Three patients had associated diseases (regional ileitis in one case and hemorrhoids in two other cases) which obscured the relative importance of the carcinoid tumor in the causation of symptoms. Symptoms had usually been present from a week or two to a few months, although one patient had constipation and rectal bleeding for one year prior to seeking medical attention.

There has been some discrepancy between the extensiveness of the lesions and symptoms. Yaker remarked[18] on the small lesions of the rectum (1.3 x 1.2 x 1.0 mm.) in his case and yet the patient complained of some difficulty with bowel movements and of having an obstructing sensation in his rectum. However, Rigdon and Fletcher stated[8] that in their case the lesions were so numerous that one could not touch the rectal wall without touching tumor, yet, the rectal lesions were incidental findings at necropsy.

*Physical Findings and Gross Appearance of the Tumor.* In 14 cases in which the quadrant of localization in the rectum was mentioned, eight showed the lesion on the anterior wall, two on the left anterior wall, and two were described as diffusely infiltrating the rectum. One case had innumerable nodules present throughout the rectum and one of our patients showed lesions in both the anterior and posterior walls.

The type of lesions have been mentioned in 18 cases. A solitary nodule was present in 14 cases, multiple nodules in two, and annular constriction lesions in two other patients. In 10 cases in which the distance of the tumor above the anus was mentioned, five were 5 cm. above, two 4 cm., one 10 cms., one 8 cm., and one 2 to 3 cm. from the anal sphincter. Of 15 discrete solitary tumors nine were reported to be nodular, three polypoid, two sessile, and one was called a plaque. In 16 cases in which the lesion was described, 12 of them were noted to be either partly covered with mucosa or entirely submucosal. The solitary lesions ranged in size from 0.2 cm. to 1.8 cm. in diameter and averaged about 1 cm. in 13 cases. Cut surface of the lesion was mentioned in 10 cases; in seven of these a yellow color was either predominant or noteworthy, two were white and one was red-brown. Five lesions were described as freely movable.

*Differential Diagnosis.* Carcinoid tumors diffusely infiltrating the wall of the rectum cannot be clinically differentiated from an infiltrating carcinoma of the rectum. In one case such a lesion in a female patient raised a question of lymphopathia venereum. The polypoid type of carcinoid resembles grossly an adenomatous polyp or a polypoid type of adenocarcinoma. Sessile or plaque-like lesions may occur in either carcinoma or carcinoid. As previusly mentioned, the majority of carcinoid tumors of the rectum have some intact mucosa covering them or are submucosal; however, a similar finding may occur in adenocarcinoma. Furthermore, the nodular carcinoid, although the most frequent in type, makes up only a small percentage of rectal submucosal nodules. Jackman[10] has reported on 87 such lesions and only four were carcinoid tumors. Previous injection therapy, inflammatory lesions, benign con-

nective tissue tumors, and rarely malignant lymphomas, accounted for the other submucosal lesions.

It is obvious that only by histologic examination can a diagnosis be made with any degree of assurance. Even with pathologic examination there is the possibility that these lesions might be mistaken for adenocarcinoma of the rectum as has occurred in some instances in the past. The recent report of 10 cases in relatively young members of the Armed Forces[9] suggest that the lesion is more frequent than previously realized.

*Treatment.* Most authors state that the plan of choice in treating malignant carcinoid tumors of the gastro-intestinal tract is resection of the primary site and as much of the metastatic lesions as is feasible. It is well known that, as a rule, the tumor is slowly growing and patients with known metastases have lived for many years. In one recorded case[25] it has been stated that following resection of a primary carcinoid tumor of the small bowel, mesenteric metastases were noted but not removed. At necropsy 20 years later the same metastases were observed and except for some calcification were apparently unchanged.

In carcinoid tumors of the rectum the problem is somewhat complicated. Only four cases out of a total of 32 known to us have been associated with metastases. Local excision of the lesion has been followed in two cases in which a solitary rectal polyp was found, by survival periods of 9 and 2½ years without any evidence of local recurrence or metastases, and a third patient was known to be alive two years after removal of a small rectal carcinoid.[7] The fact that the lesions occur often in relatively young patients and that extensive surgery in the rectum carries with it considerable discomfort and annoyances associated with colostomy, is a factor to be weighed against the apparent low grade malignant nature of the neoplasm.

From our limited experience of only three cases we can no more than point out what appear to be salient features. Our Case 1 died with generalized metastases two years after the onset of his symptoms. Case 2 had liver, kidney and lymph node involvement and was severely debilitated when last seen about two years after the onset of her symptoms. It is very difficult to differentiate, on histologic appearance, those lesions that have been associated with metastases and those that have not been, although two of our cases with metastases showed areas of atypical cells (Fig. 3). If, on rectal examination, an infiltrating type of lesion is found, a malignant type of lesion is implied but this is not infallible. Infiltrating and annular constricting lesions have been associated with metastases in two cases, but liver, bone marrow, and lymph node metastases were present in a case showing only a solitary, pea-size rectal lesion.[16] In one case showing almost complete involvement of the rectal wall with innumerable nodules, autopsy revealed no metastases.[8] The age of the patient may be significant, for the nine-year survival after local excision was in a 19-year-old girl and the ages of the patients showing metastases were 45, 51, 64, and 71 years. However, at least two cases of malignant carcinoid

tumors of the small intestine have occurred in patients under 40 years of age[26] so that the age *per se* may not be too significant.

It would appear that solitary freely movable lesions in young patients might be excised locally and the patient carefully followed for signs of local recurrence or metastases. Annular constricting or diffusely infiltrating lesions in middle-aged or elderly patients would appear to call for extensive surgery such as that used in adenocarcinoma of the rectum. Cases lying between these two extremes call for considerable clinical judgment and pathologic acuity, and definitive lines of therapy probably will be drawn only after a large number of cases has been properly assayed.

The application of radiation therapy to carcinoid tumors of the rectum or their metastases has not been reported, to our knowledge. Several authors,[4, 27, 28] have observed that metastases from carcinoid tumors arising elsewhere in the gastro-intestinal tract appear to respond well to irradiation if the primary tumor is removed. These reports suggest that some carcinoids and their metastatic lesions may be radiosensitive.

## SUMMARY

Three cases of carcinoid tumor of the rectum have been reported. One patient showed at necropsy metastases to the liver, kidney, thyroid and distant lymph nodes. In the second patient abdominal exploration revealed metastases to the liver, kidney region, and distant nodes. In the third patient only a small polyp was found in the recto-sigmoid area.

Thirty-two cases of carcinoid tumor of the rectum have been reported (including our three). Of these, four (including our two) have been associated with distant metastases.

The pertinent literature is reviewed, the symptoms and signs summarized, and the differential diagnosis, pathology and treatment of these neoplasms briefly discussed.

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SINCE SUBMISSION OF THIS REPORT THE AUTHORS HAVE HAD AN OPPORTUNITY TO REVIEW 5 MORE RECTAL CARCINOID TUMORS, IN 2 OF WHICH THERE WAS AT LEAST INVASION OF THE RECTAL WALL AND ADJACENT TISSUES. IN ADDITION, WE HAVE NOTED A REFERENCE BY DUKES* TO 9 CASES OF CARCINOID TUMOR OF THE ANO-RECTAL REGION SEEN BY HIM IN A STUDY OF 203 CARCINOMAS OF THAT AREA. THREE OF THE CARCINOIDS WERE DISCOVERED IN SURGICAL SPECIMENS CONTAINING CARCINOMA OF THE RECTUM. IN ONLY ONE CASE WAS ADEQUATE FOLLOW-UP AVAILABLE: THE PATIENT WAS A 34-YEAR-OLD WOMAN WHO WAS WELL AND FREE OF RECURRENCE 9 YEARS AFTER LOCAL EXCISION OF THE LESION.

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# MORBIDITY AND MORTALITY IN TALC GRANULOMA: REPORT OF A FATAL CASE * †

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DESPITE THE RAPIDLY INCREASING NUMBER of reports of postoperative complications and morbidity in which talcum powder has been incriminated as the etiologic factor, this noxious agent continues in use. The purpose of this paper is to re-emphasize the incidence of morbidity due to this complication and report a case in which talc granuloma not only necessitated an unprecedented number of laparotomies but ultimately caused the death of the patient.

## INCIDENCE AND MORBIDITY

When Antopol[1] in 1933 described the first case of intraperitoneal granuloma due to talc, he started a trend of thought which has since been developed and reported upon by many investigators. Antopol, as others before him, was primarily interested in lycopodium spores as a pathogenic factor in the production of tubercle-like granulomatous lesions. Indicative of the frequency and morbidity are the numerous clinical reports which have appeared in the literature since 1933. Most notable are those of Feinberg[2], Owen[3], Ramsey and Douglass[4], McCormick and Ramsey[5], Byron and Welch[6], Ramsey[7], and German[8], in which two to five laparotomies were necessitated for the relief of obstruction due to talc granuloma. German[8] reported one case in which five previous laparotomies had been performed. Lichtman Et Al[9] reported talc crystals with surrounding foreign body response in 21 of 100 consecutive surgical cases in which there were dense adhesions resulting from multiple previous operations.

In addition to intraperitoneal granulomas due to talc, Antopol and Robbins[10], Erb[11], Antopol[1], Cline[12], Fienberg[2], Ramsey and Douglass[4], and Lichtman Et Al[9,X] have reported identical lesions in the skin, vagina, rectum, eye, gallbladder, healing surgical wounds, and brain. Lichtman reported granulomas developing in scars from two months to 36 years after talc was implanted in the skin. In the Veterans Hospital, Wood, Wisconsin, Ross[13] has found a large number of granulomatous lesions of the foreign body type among the routine surgical specimens. Of these most were definitely identifiable as talc granulomas. This does not take into account the many draining sinuses occurring in operative wounds which were not biopsied and examined for talc crystals.

### EXPERIMENTAL PRODUCTION OF LESIONS

Miller and Sayers,[14, 15, 16] reporting on an excellent series of experiments with various dusts in 1933 and 1934 pointed out that the peritoneal response to foreign bodies falls into one of three types e.g.: (1) absorptive, in which the foreign material is absorbed and no permanent lesion is formed; (2) proliferative, in which there is tubercle formation and proliferation of fibrous tissue (talcum falls into this class) ; (3) inert, in which the foreign material remains in the peritoneal cavity but produces no reaction at all. Owen[3] in 1936 produced talc granulomas experimentally in the peritoneal tissue of rabbits which were grossly and histologically identical to those removed from the peritoneum of a young woman two years after appendectomy. Bethune[17] in 1935 demonstrated the effectiveness of commercial talcum powder in producing pleural adhesions in preparation for lobectomy. Lichtman Et Al,[9] and Lee and Lehman,[18] in well-controlled experiments on dogs, have conclusively demonstrated the ability of talc to produce dense adhesions in the peritoneal cavity, and to cause and perpetuate both external and internal fecal fistulas.

### COMPOSITION AND PORTALS OF ENTRY

Kroneberg[18] found the composition of ordinary commercial talc used on surgical gloves to be talc 82.7%, calcium carbonate 8.7%, magnesium carbonate 7.6%, 55% of the particles being less than 5 microns in diameter. Weed and Groves,[20] in observations on 4,569 operations at the Central Surgery of the Indiana University Medical Center, showed that perforations of gloves occurred in 22.6% of all gloves used, thus providing a portal of entry for talc crystals. Our own observation reveals an additional portal in that rubber drains are liberally powdered with talc for autoclaving. The impossibility of completely removing all talc crystals from rubber drains or gloves is easily demonstrated. Regardless of how thoroughly they are washed, subsequent examination under the polarizing microscope will reveal many birefringent crystals still clinging to the rubber.

Although much has been written of complications and morbidity due to talc granulomas, we were unable to find any report in which death was ascribable to this lesion and, consequently, no records of autopsy findings in human material. As previously stated, the largest number of multiple operations was the five reported by German.[8] In the case herein presented fifteen operations were performed, death ultimately ensued, and an autopsy was done. It should be stated that this patient was operated upon initially while in the Army and only the last two surgical procedures were carried out in the Veterans Hospital at Wood, Wisconsin.

### REPORT OF A CASE *

A.L.M., VA-93462, had no serious illness prior to 1942 when her present illness actually began.

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* This case is published with the permission of Dr. Forrester Raine, Senior Consultant in Surgery, who was the operating surgeon.

*History and Clinical Course.* In December of 1942, at the age of 36, the patient had her initial operation for intestinal obstruction. At surgery an adenocarcinoma of the descending colon was found. The tumor together with 10 cm. of colon was removed and a primary end-to-end anastomosis was made. On her seventh postoperative day there was a disruption of the wound which required secondary closure. A draining sinus persisted in the operative wound. Approximately three months after the first operation she became completely obstructed and was again operated upon. At this operation a stricture of the descending colon was found at the site of the previous anastomosis and a Mikulicz type



Fig. 1.—Segment of terminal ileum, removed at surgery, showing numerous granulomatous nodules.

resection was done. Pathologic examination of this specimen showed a granulomatous-type lesion with foreign body giant cells and was thought by the pathologists to be due to suture material (this examination was done elsewhere and, unfortunately, the slides could not be obtained for re-examination under the polarizing microscope).

Between her first operation and her final admission to this hospital she was operated upon 14 times for adhesions and intestinal obstruction. Her story was monotonously similar for all these episodes, the sequence being surgery, hyperperistalsis and pain, alternating diarrhea and constipation, complete obstruction with nausea and vomiting, and

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. finally more surgery. At one of these operations, in February of 1944, a cholecystectomy was done. In June of 1946 an exclusion of the terminal 24 inches of ileum was effected by side-to-side anastomosis with the ascending colon. The terminal 24 inches of ileum which was an inseparably adherent, non-functioning mass was thus by-passed by the fecal current. Following this procedure the patient was able to get along fairly well although discomfited by persistent distention of the right lower abdomen and 12 to 14 loose watery stools daily. During this time she perspired freely, was easily fatigued, had insomnia and



FIG. 2.—Remains of intestinal tract as seen at autopsy. The probe is in the cecal fistula. The entire mesentery and bowel show chronic, granulomatous changes.

had daily swelling of her feet and puffiness of her eyes. She re-entered the hospital in January of 1947 because of severe headache and the persistent diarrhea. In February, 1947 she again became completely obstructed. Conservative treatment was hampered by a severe sensitivity to rubber, and surgical intervention was necessary. At operation the peritoneal cavity was found to be almost completely obliterated on the right side by dense adhesions. Adhesions were freed and the excluded portion of ileum comprising the terminal 24 inches was excised in toto. On the 10th postoperative day the wound disrupted and a fistula developed. All measures directed toward controlling the fistula and maintaining nutritive balance failed and the patient died on the 86th postoperative day.

## SURGICAL SPECIMEN

Pathologic examination of the portion of ileum removed in February of 1947 showed a chronic adhesive peritonitis with small greyish-white nodules scattered over the serosal surface (Fig. 1).
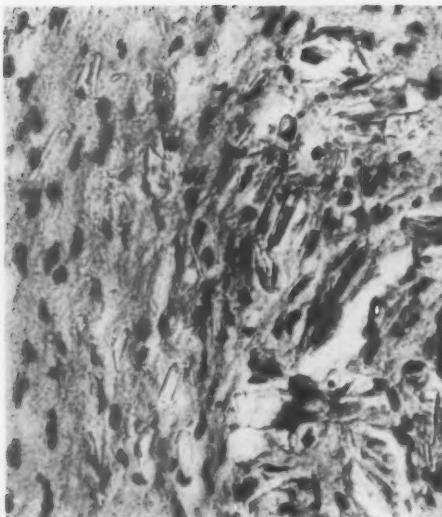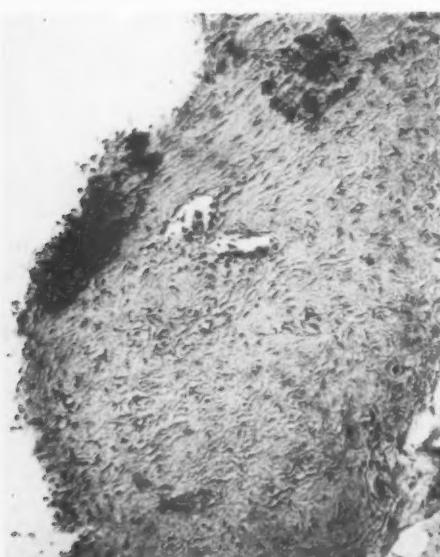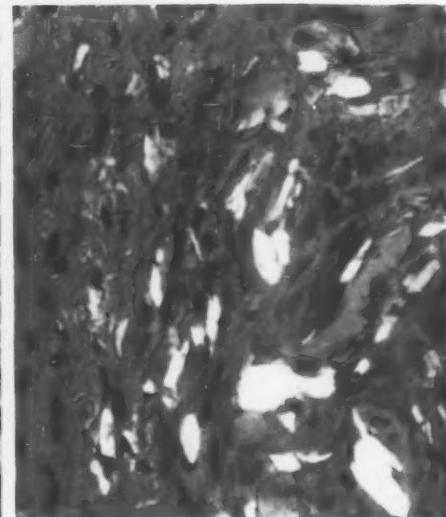


FIG. 3A.—Granuloma on the surface of the right ovary. Hematoxylin and Eosin x 90.
FIG. 3B.—Higher magnification under ordinary light. Talc crystals are visible. Hematoxylin and Eosin x 400.
FIG. 3C.—The same field under polarized light which makes the crystals more clearly visible. Hematoxylin and Eosin x 400.

Microscopic examination showed a thickening of the serosa with fibrosis, lymphocytic infiltration, and foreign body giant cells which had engulfed crystalline material. Examination under the polarizing microscope showed this crystalline material to be composed of birefringent crystals which were morphologically identical with talc crystals.

### AUTOPSY FINDINGS

At autopsy the body presented the typical emaciated appearance of death by starvation. The cause of death was inanition due to chronic adhesive peritonitis. The gross anatomical findings were: (1) ulcerative gangrene



A                                    B
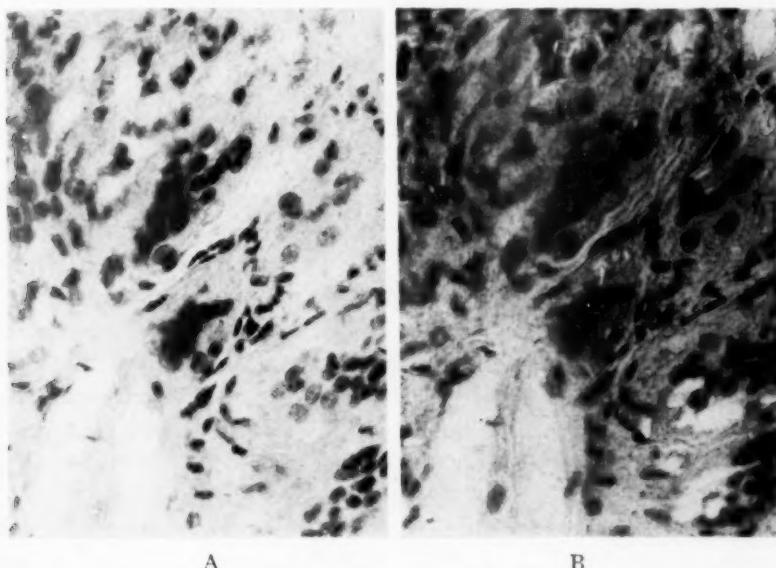
Fig. 4A.—Section of peritoneal nodule (ordinary light) showing typical foreign body granuloma formation with talc crystals and large foreign body giant cells. Hematoxylin and Eosin x 400.

Fig. 4B.—Same field under polarized light to show up crystals more clearly. Hematoxylin and Eosin x 400.

of the cecum with a fistula through the right abdominal wall; (2) intra-abdominal fistulous tract from the cecum to the right pelvis; (3) localized sero-fibrinious peritonitis of the pericecal region and pelvis; (4) diffuse chronic adhesive peritonitis; (5) diffuse talc granulomatosis of the peritoneal surfaces; (6) ulcerative esophagitis.

Only the abdomen merits description in this report. All that remained of the gastro-intestinal tract was the stomach, duodenum, four loops of small bowel, and approximately two-thirds of the large bowel. The omentum and remaining loops of small bowel were firmly adherent to the anterior abdominal wall at the medial edge of the fistulous tract forming a pocket in the right

half of the abdomen containing necrotic and gangrenous cecum and ascending colon. This pocket was connected with a similar pocket in the right half of the pelvis by an intraabdominal fistula from the lower portion of the cecum. The right ovary, Fallopian tube, and uterus were firmly bound to the right pelvic wall by dense adhesions. Scattered throughout the peritoneal surface and in the mesentery of the bowel there were numerous small greyish-white, tubercle-like nodules which varied in diameter from one to five mm. (Fig. 2). Mesenteric lymph nodes were hypertrophic.

## MICROSCOPIC EXAMINATION

All organs microscopically showed degenerative changes. Sections of the bowel showed gangrene and chronic enteritis. The intestinal wall was thickened by a chronic inflammatory process involving the serosal surface and characterized by lymphocytic infiltration, fibrosis, and foreign body giant cells containing birefringent talc crystals. Mesenteric lymph nodes showed a chronic lymphadenitis without the presence of talc crystals. Kidneys showed a nephrosis and calcinosis manifested by deposits of calcium in the convoluted tubules. Sections through the right ovary showed a chronic granulomatous perioophoritis. Figure 3a is a low power field of a section of the right ovary showing a typical granuloma on the serosal surface with an underlying marked foreign body reaction. Figure 3b is a high power field of the same section showing the marked chronic inflammatory reaction with fibrosis, foreign body giant cells, and talc crystals. Figure 3c shows the same field under polarized light which brings out the crystals more clearly. Sections of the nodules found in the peritoneal surface show a typical foreign body granuloma formation characterized by lymphocytic infiltration, foreign body giant cells containing birefringent talc crystals and early fibrosis (Fig. 4a and 4b).

## DISCUSSION

This patient was cured of her carcinoma since no evidence of recurrence or metastases was found at autopsy. The 15 subsequent operations were all necessitated by intestinal obstruction due to adhesions which we feel can be directly ascribed to talc granuloma. Both the gross and microscopic appearance of the bowel removed at surgery and the sections taken at autopsy support a diagnosis of talc granuloma. The massive, dense adhesions, the small, greyish-white nodules in the peritoneum, and the formation of uncontrollable fecal fistula are typical of the pathologic changes described by Lichtman,[9] Lee and Lehman,[18] and other investigators in both human and animal material. The finding of large numbers of birefringent crystals surrounded by a foreign body inflammatory reaction is conclusive evidence that talc was the pathogenic agent in the production of this clinical and pathological picture. The occurrence of a chronic lymphadenitis without the finding of talc crystals in the lymph nodes themselves is explained by Lichtman[9] in his description of the pathogenesis of talc granuloma as being due to the fact that talc immobilizes phagocytes without destroying them, so that migration from the original site is limited, thus producing circumscribed granulomas.

The role of infection in the formation of fibrous adhesions and the activation of granulomatous lesions due to talc is debatable. Lichtman,[9] along with German,[8] feels that infection is an important factor whereas Lee and Lehman[18] were able to demonstrate, in dogs at least, that neither trauma nor infection were necessary to the formation of granulomas or adhesions. It is probable that in the case under discussion, both trauma and infection contributed materially to the severity of the reaction. An interesting point for speculation is the fact that this patient was sensitive to rubber, reacting promptly and violently to even a gastric suction tube. This may also have been a factor in the severity of the peritoneal reaction and might be indicative of an unusual sensitivity to other foreign substances.

An additional interesting sidelight in this case was the finding of nephrosis and calcinosis in the microscopic examination of the kidneys. These findings in this particular patient with a long history of intestinal obstruction and vomiting (and with marked shortening of the gastro-intestinal tract) are typical of the changes described by Martz.[21]

Since talcum powder has been so conclusively demonstrated to be a dangerous agent in surgery and one whose deleterious effects in producing postoperative complications, increasing morbidity, and even causing death, far outweigh its advantages, it seems logical that its use should be discontinued. In the past several years numerous investigators have been searching for a suitable substitute for talcum powder. Of these, Seelig et al[22] in 1943 recommended the use of potassium bitartrate which they found would meet the physical requirements of steam sterilization and at the same time was inoncuous when placed in the peritoneal cavity. More recently, Lee and Lehman,[18] after a well-controlled series of experiments with several agents, recommended the use of a commercially prepared corn starch derivative which proved to be, in both laboratory experiments and clinical use, a perfectly satisfactory substitute for talcum powder in all respects.

### SUMMARY AND CONCLUSIONS

1. From a survey of the literature and from our own observations we must conclude that talcum powder is a dangerous agent which has no place in modern surgery. The complications and morbidity which confront the surgeon and the economic loss to the patient, all ascribable to talc, are staggering.
2. In the case herein presented talcum powder was undoubtedly directly responsible for the death of the patient.
3. Of the substitutes offered to date, the modified corn starch preparation recommended by Lee and Lehman seems best to fulfill all the requirements of a dusting powder for use on surgical gloves and drains.

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# AN UNUSUAL COMPLICATION OF A
## MECKELIAN DIVERTICULUM *

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THE PERSISTENCE OF THE vitello-intestinal duct in man, in whole or in part, is variously estimated to occur in from 1 to 2 per cent of instances. The early human embryo is imperfectly differentiated from a large and conspicuous yolk sac and communicates with this sac widely by its ventral surface. This communication forms the lumen of the vitelline duct; it is conspicuous during the first month of gestation, but it usually disappears by the sixth or seventh week of fetal life. In cases in which the closure and obliteration of the vitelline (umbilical) duct are imperfectly effected before birth, a portion, or even all of the duct may persist as a pervious tube. The anomaly caused by a persistent vitelline duct is termed "Meckel's diverticulum." The vitelline duct is accompanied in the embryo by the umbilical vessels. The latter, like the duct itself, may persist and in adult life may be found close to the diverticulum; they may have an independent course or they may lie along the free border of the mesentery of the diverticulum.

Eisendrath recorded six conditions which may be found to exist at birth and which are due to the persistence of the vitelline duct and umbilical vessels: (1) a complete canal which opens at the umbilicus and communicates with the lumen of the ileum; (2) a canal which opens at the umbilicus and ends blindly at a variable distance within the abdominal cavity; (3) a persistent intermediate portion of the duct which has no communication externally at the umbilicus or internally with the ileum, but which forms a cystoma owing to retained secretion; (4) a canal which is limited to the proximal end and which opens into the ileum; (5) a cord containing the umbilical vessels which may persist as an independent structure and which may be attached to the umbilicus separately. This vascular cord may take an independent course, the vessels may run along the free border of the mesenteriolum of the diverticulum or they may run from the diverticulum to form a cord which is commonly known as the terminal ligament; and (6) an absent or rudimentary diverticulum, in which event the only evidence of the presence of a congenital condition is a cord which contains the umbilical vessels, or traces of them and which extends from the mesentery to the umbilicus.

Numerous reports of the occurrence of complications secondary to Meckel's diverticulum are recorded in the literature. These include intestinal obstruction due to intestinal volvulus, hemorrhage due to ulceration of aberrant gastric mucosa in the lumen of the diverticulum, intussusception, perforation,

neoplastic involvement of the diverticulum, calculus formation in the diverticular pouch and umbilical fecal fistula.

Reports of an external fistula presenting at the umbilicus, owing to Meckel's diverticulum, have been confined to infants or children of a very early age. The development of an external fecal fistula in adult life owing to a patent vitelline duct, with persistent attachment at the umbilicus, we believe to be an uncommon occurrence. We were unable to find any record that such a complication had been previously reported.

We recently had the opportunity of seeing a patient in whom an external fecal fistula, secondary to Meckel's diverticulum, developed late in life. Because of the unusual nature of the case and the difficulties presented in diagnosis we felt it would be worth while to report it.

### REPORT OF CASE

A 75-year-old widow had always been in good health except for a moderate hypertension of many years' duration. She had undergone cholecystostomy for cholelithiasis 30 years before admission to the clinic and had recovered therefrom without incident. Four days prior to admission, after the patient had played rather strenuously with her young grandson, generalized crampy abdominal pain, followed by vomiting and moderate distention of the abdomen developed. She consulted her family physician, who performed a roentgenologic examination of the stomach and colon and found them normal. She became progressively more ill and was referred to the clinic for an opinion.

At the time of admission the patient was very ill, toxic and dehydrated. The tongue was dry and furred. The blood pressure was 170 mm. of mercury systolic and 106 mm. diastolic. Examination of the chest revealed depression of breath sounds, with fine crepitant râles at the base of the right lung. The abdomen was distended and moderately tympanitic; few peristaltic sounds were audible. About the umbilicus was a red indurated area of cellulitis which measured approximately 3 inches (7.5 cm.) in diameter, with an area of subcutaneous crepitus at its upper edge. The clinical picture was that of ileus with complicating bronchopneumonia. It was difficult to account for the periumbilical cellulitis.

The voided urine contained albumin, grade 2 (on the basis of 1 to 4, in which 1 represents the mildest, and 4 the most severe condition), numerous hyaline and a few granular casts, and a few erythrocytes and leukocytes. The Kline flocculation test of the blood serum was negative. The hemoglobin measured 14.6 Gm. per 100 cc. of whole blood and the leukocytes numbered 6,000 per cubic millimeter. The value for blood urea was 144 mg. per 100 cc. and for the serum chlorides, 544 mg. per 100 cc. A roentgenogram of the chest showed pulmonary congestion and beginning bronchopneumonia on the right side. A roentgenogram of the abdomen revealed some distention of the coils of the small intestine.

Food could not be retained because of nausea, so fluids were given intravenously. Because of the pneumonia, 2.5 Gm. of sodium sulfadiazine were given intravenously every day. The abdominal distention was relieved by intestinal intubation.

Despite every supportive measure available, the patient became progressively more ill. There was persistent fever, with a temperature which varied between 101° and 103° F. (38.3° to 39.4° C.). The pneumonia became more extensive. Necrosis and ulceration developed in the area of periumbilical cellulitis and foul purulent material, with a strongly fecal odor, began to drain from this point on the third hospital day. Death occurred on the sixth hospital day.

At necropsy we found a small opening at the umbilicus from which was oozing thin purulent fluid with a fecal odor. On opening the peritoneal cavity no evidence of

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inflammation was noted. A bandlike structure arose from the ileum 15 cm. proximal to the ileocecal valve and extended to an attachment at the umbilicus. This appeared to be a persistent vitello-umbilical duct (Meckel's diverticulum).

There was an abnormal mobility of the cecum and ascending colon, these structures lying in the left half of the abdomen. There was chronic ulcerative cholecystitis with cholelithiasis. The gallbladder contained 150 cc. of purulent fluid and five black stones which averaged from 0.3 to 0.6 cm. in diameter. Thrombosis of the left iliac and femoral veins had led to bilateral pulmonary embolism, and small infarcts of the lung were



FIG. 1.—Connection of the Meckel's diverticulum with the antreior abdominal wall. The diverticulum has been opened longitudinally and the probe is in the fistula. The arrow shows the most distal point of contact of the diverticulum with the ileum.

present. Incidental findings were a traction diverticulum of the esophagus associated with healed tuberculosis of the lungs and hilar lymph nodes, and diverticulosis of the sigmoid. The immediate cause of death was considered to be extensive bronchopneumonia which had involved both lungs.

On closer examination, the Meckel's diverticulum (Fig. 1) was found to arise from the lumen of the ileum at an oblique angle, the proximal 4 cm. of it being incorporated in the wall of the ileum; both the diverticulum and the ileum were covered by a common serosa which, in effect, produced a double lumen tube. The opening into the ileum was approximately 1.3 cm. in its greatest diameter, and the average diameter of the proximal portion of the diverticulum was 0.8 cm. The length of the diverticulum, from its point of contact with the bowel wall to its junction with the anterior abdominal wall at the umbilicus, was 17 cm. The distal portion of the diverticulum, for a distance of 6 cm., ran parallel to the anterior abdominal wall and was covered by parietal peritoneum.

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The terminal 2.5 cm. of the diverticulum was gray in appearance and necrotic, but it was intact throughout, except for the tip. A fistulous tract began at the tip of the diverticulum, coursed through the subcutaneous fat and an abscess in the subcutaneous tissue, and opened externally at the midpoint of the umbilicus. The subcutaneous abscess contained approximately 4 cc. of pus. There was no gross evidence of ulceration on the mucosal surface of the diverticulum proximal to its attachment to the anterior abdominal wall.

Microscopic examination of sections taken from the distal portion of the diverticulum showed chronic suppurative inflammatory changes with active proliferation of fibroblasts and capillary loops. Much of the mucous membrane of this portion of the diverticulum was destroyed. The lumen of the diverticulum was filled with polymorphonuclear leukocytes and necrotic debris, and it communicated freely through a necrotic wall with an abscess in the fibrous and adipose tissue of the anterior abdominal wall. Sections taken from the proximal portion of the diverticulum showed a minimal amount of acute inflammatory exudate on the serosal surface; otherwise they were not remarkable. There was no evidence, from any section taken, of generalized peritonitis. A section of the diverticulum at its junction with the anterior abdominal wall confirmed the gross impression that it was covered with peritoneum; this led to the conclusion that the diverticulum was congenitally located in the position in which we found it, and that it had not become secondarily attached as a result of an inflammatory process.

## COMMENT

Aberrant gastric mucosa is sometimes found in Meckel's diverticulum. Such aberrant tissue has led to ulceration and severe bleeding from the gastrointestinal tract. It is not unreasonable to believe that an ulcer which develops in this way could perforate and could result in an abscess and fistula similar to those noted in our case. A meticulous search of serial blocks of tissue afforded no confirmation whatsoever of this postulate. However, since the mucosa was completely destroyed in some of the sections, that such a possibility was existed in our case cannot be positively excluded. More probably the sequence of events was, as our evidence suggests, inflammation of the diverticulum which led to necrotic diverticulitis with perforation, abscess and ultimately fistula formation. This complication of Meckel's diverticulum in the eighth decade of life is undoubtedly unusual, but that it does occur, again emphasizes the fact that Meckel's diverticulum is a constant hazard to a patient who harbors one, even though he may for many years be unaware of its presence. In a review of the literature, two interesting cases of umbilical fistula due to Meckel's diverticulum were encountered. Neither of these, however, resembled the case we are reporting. In one of these cases, Ratnayeke reported the successful repair of a fecal fistula due to a patent vitelline duct in a six-week-old infant. In the other case[3] a draining umbilical sinus developed in a healthy twenty-year-old man. At the time of operation the sinus was found to communicate with a sac situated under the umbilicus. The sac proved to be a remnant of the distal end of the vitelline duct. There was no connection between the sinus and the ileum in this case.

## SUMMARY

We have reported an unusual complication of a meckelian diverticulum. This was the occurrence, in a 75-year-old patient, of an external fecal fistula

which presented at the umbilicus and which communicated with the ileum through a persistent vitello-intestinal duct. The diverticulum had caused no symptoms prior to the patient's last illness. We were unable to find, in the literature, record of a previous similar complication in Meckel's diverticulum.

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# CHYLOUS MESENTERIC CYST*

## Case Report

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WHEN CONSIDERING the differential diagnosis of an abdominal mass, it is customary to include a mesenteric tumor among the possibilities. A brief review of the literature will show that such tumors are among the rarest of abdominal neoplasms. Furthermore a chylous cyst is one of the rarest of mesenteric tumors. Some idea of its rarity may be obtained from the statistics assembled by Slocum[7] which show that only six cases were recorded at the Massachusetts General Hospital from 1900 to 1926; only one case was noted in over 93,000 admissions at the University of California Hospital and the Los Angeles General Hospital had only one case in over 188,000 admissions. While these figures are from reports of over ten years ago, the frequency of this condition has not increased. A recent case report by Beahrs and Judd[1] states that there have been seven cases at the Mayo Clinic in more than one million patients. The case which I am reporting is the first one recorded at the Jewish Hospital in over 160,000 admissions since our modern recording system was started 20 years ago.

It is important to specify what is meant by a chylous mesenteric cyst as much confusion exists in the literature. Various types of mesenteric cysts are described which need not be enumerated, but the chief confusion exists between a true chylangioma and an enterocystoma due to cystic dilatation of a congenital duplication of the bowel. This differentiation is most important according to Ladd and Gross[5] because they are pathologically different and require different forms of treatment. The duplication is a thickwalled structure which has all the intestinal layers in its wall. It usually lies immediately adjacent to the bowel between the folds of the mesentery and the musculature of the duplication is so intimately associated with that of the intestine that they cannot be separated without injury to the latter. The blood supply of the duplication is the same as that of the adjacent intestine so that the duplication cannot be removed without destroying the intestinal blood supply. The true mesenteric cyst on the other hand, is thin-walled and has no muscular coat or mucosal lining. While it may lie against the mesenteric surface of the intestine, there is a cleavage between the two so that it can usually be excised without injuring the bowel or its blood supply. These cysts could arise by obstruction of a lymphatic trunk, but the absence of demonstrable inflammation or other fibrosing lesion in the mesentery in such cases leads Ladd and Gross to doubt this theory. They believe that these cysts develop from misplaced bits of lymphatic tissue which proliferate and then accumulate fluid because they do not possess communications with the remainder of the lymphatic system. The source of the chylle in these cysts has not been definitely determined.

*Submitted for publication, December 1947.

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Dowd[2] in a classic paper believed that it was an effusion into a preformed cyst because the rich anastomosis of peritoneal lymphatics seems to preclude cyst formation by obstruction to even many channels. On the other hand Ewing[3] is of the opinion that they are true chylangiomata due to congenital or acquired obstruction of lacteals.

Like many other types of cyst, these lesions seldom cause marked symptoms until complications develop. The most common complication is partial intestinal obstruction with its accompanying cramping pain. When this develops in the presence of a palpable mass, it is likely that a torsion of a tumor would be suggested, whereas, due to its location between the mesenteric leaves, these cysts rarely become twisted. In addition to intestinal obstruction which is common (30 to 50%) and torsion which is rare, Thompson and Chambers[8] state that other complications include peritonitis secondary to obstruction or rupture, hemorrhage into the cyst, rupture of the cyst either spontaneously or due to trauma, and incarceration of the cyst in the pelvis. In cases where complications have developed there is little time for delay so that an accurate diagnosis is seldom made before operation. However, when it is safe to take time to make leisurely studies Hinkel[4] believes that roentgenologic methods are of value. In three patients he was able to localize the lesion by studying its relations to the surrounding structures. This is done by giving a barium meal or enema followed by roentgenoscopic palpation of the lesion.

When confronted with one of these rare lesions the surgeon has a choice of several procedures. Most authors agree that the ideal solution is enucleation of the cyst from the mesentery if this can be done without interference with the blood supply to the bowel. According to Roller[6] the mortality of such treatment is 9 per cent whereas if it is necessary to add intestinal resection, the mortality is tripled. In some cases it may be inadvisable to attempt to remove the cyst either with or without intestinal resection and in these instances the sac may be marsupialized. The recovery rate after such operation is high but there may be a persistent sinus, although in several cases reported the sinus closed within a reasonable time.

### REPORT OF CASE

A single girl, age 17, was admitted to the Jewish Hospital on the evening of October 29, 1947 complaining of abdominal pain. On the preceding day she had felt tired and slept poorly. She awoke with a pain around the umbilicus and ate little breakfast. The pain continued all day although her bowels moved and there was no nausea or vomiting. Her temperature and pulse were normal. Examination on admission revealed a mass in the mid lower abdomen which was not movable and was dull on percussion. No tenderness was present over the appendix but there was moderate tenderness over the mass. Bimanual examination by rectum, after catheterization of the bladder, revealed the uterus to be normal size and anterior and a mass about the size of a large orange was situated above the uterus. This was thought to be an ovarian cyst, probably dermoid and since there was abdominal pain, it was thought that partial torsion had occurred. Operation was advised.

*Operation.*—The abdomen was opened through a low right paramedian incision and a cystic mass was exposed at once. Examination of the pelvis showed normal pelvic

organs and the mass was not arising from the pelvis. Attempts to deliver the cyst from the wound were not successful until the wound was enlarged upward. After extending the incision, the mass was delivered along with several loops of lower jejunum. It was then determined that it was a cyst between the leaves of the mesentery with the small bowel stretched over the periphery. It was decided to attempt enucleation and an incision was made along the left leaf of the mesentery perpendicular to the bowel. The wall of the cyst was so thin that it was perforated and about a pint of milky fluid was expelled. The edges of the cyst were grasped with hemostats and the cyst wall was separated from the leaves of the mesentery. The cyst was unilocular and extended down to the mesenteric root. It was enucleated without interference with mesenteric vessels and the incision in the mesentery was closed with a continuous catgut suture. The abdomen was closed in layers without drainage. The convalescence was uneventful and she was discharged from the hospital on November 9, 1947.

SUMMARY.—Chylous cyst of the mesentery has an incidence of one case to 150,000 hospital admissions. It is seldom diagnosed before operation since it usually causes no symptoms until important complications arise. The true mesenteric cyst must be differentiated from the enterogenous cyst secondary to duplication of the bowel since the surgical problems involved are different. The manner in which the chyle enters the cyst is speculative. The ideal treatment is simple enucleation but intestinal resection may have to be done in addition. If the cyst wall cannot be removed with safety it may be marsupialized with reasonable hope of cure. A case is reported in which a simple enucleation was done with prompt recovery.

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